WINDOWS

WINDOWS

in modern architecture

GEOFFREY BAKER & BRUNO FUNARO

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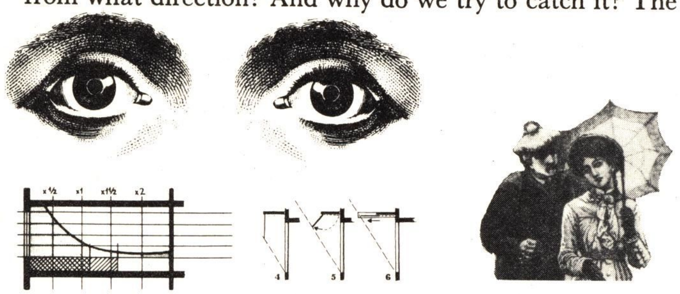
CONTENTS

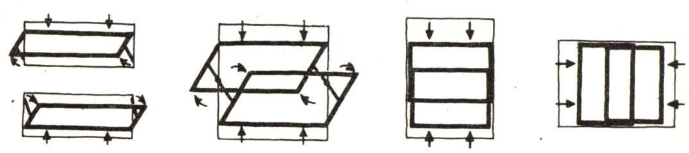
A review of those factors which should control the fenestration of buildings. Showing that the purpose of a window is to let in daylight. But what is daylight? and when? and from what direction? And why do we try to catch it? The fundamentals of daylight control, how to affect its amount, direction and quality, where to put it.



And then there is also the view to consider. How do you want it: framed, all-clear, tall, or broad? Are you sure you really want it?

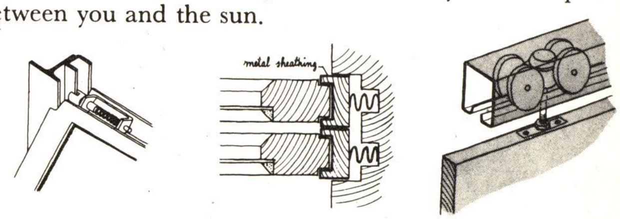
Even today window design is profoundly influenced by its *historical background,* generations of tradition, experiment, technical achievement. It has been diverted by political, social and aesthetic discouragements, wars, taxes, Golden Rules. And there is still that dispute about the pros and cons of combining light and ventilation in a single opening, as do most stock windows today.

There is a multiplicity of different types in opening sash, but when boiled down to essentials—the methods of operation — they fall into a more comprehensible and very much shorter list.

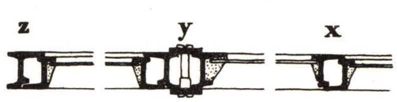


An illustrated survey of hardware used in both stock and custom-made windows of every type and brand: locks and handles, balances, hinges and roller tracks, single and multiple operators. Also weatherstripping, screens and storm sash, complete and in parts.

Then finally, a section on sun shades, not the fundamentals of sunlight calculation and control (that you will find on pages 131 through 141), but a brief survey of accessory equipment such as awnings, jalousies, Venetian blinds, curtains, etc., any of which may be interposed between you and the sun.

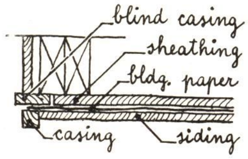


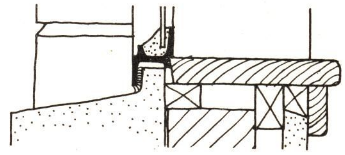
A succinct guide to standard, mass-produced sash both wood and metal. In this bird's-eye view the products of all the different window manufacturers are set in a single, logical perspective for the first time. The characteristic design features of each of the principal window types are described in specially drawn details, and the *reason* for each of these details is noted in the explanatory text.



Explaining the principles upon which all window installations are based, and the application of these to wood and metal sash. This enables the designer to go ahead confidently with the creation of his own details for that vital

joint between the building itself and its windows, whether those windows are to be built-in or set in a prepared opening. For reference and comparison there are also four pages of classified detail drawings to show standard, tested installation details designed for almost every sort of wall construction commonly used.

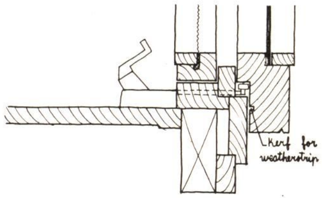


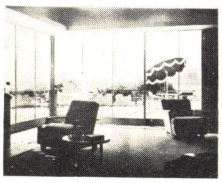


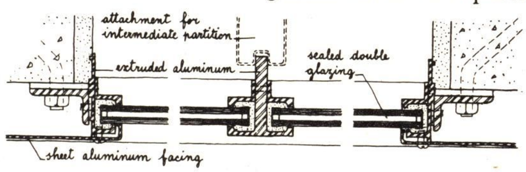
63 WINDOWS IN USE . . . . pages 50 through 122

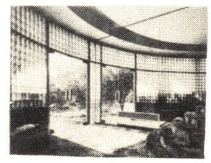
Complete documentation on the window design of sixty-three buildings of various types. Each one is fully illustrated and described in photographs, special scale drawings, diagrams, and explanatory text.

There are private houses here, and stores, factories and schools, an airport control tower and a church. There are several office buildings and apartment houses, two trains and a hospital. Naturally in these varied buildings are found windows of every sort: fixed sash and ventilating louvers, double-hung and continuous windows, casements and skylights, awning and accordion windows, sliding glass walls, bay windows, monitors, and many more of special and ingenious design. Illustration and text together cover not only the purpose of each window and its relation to the structure of the building, but also those important details of construction and installation which are so often neglected in more superficial accounts.



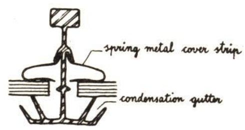






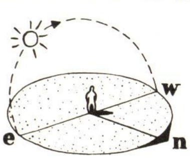
GLASS: PROPERTIES AND TYPES . . . . pages 123 through 130

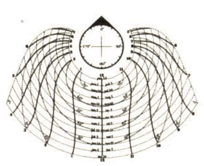
Glass is still the basic raw material of windows. It can be used to best advantage only when its special properties and limitations are understood. Representative types of figured glass and glass block are graded photographically according to their through-visibility. Principles and practice of glass installation, including skylights and puttyless glazing, glass block and frameless double-hung windows.



HOW TO CONTROL SUN, LIGHT, HEAT . . . . pages 131 through 142

The ABC of sun movement. A clear understanding of the sun's changing path throughout the year is essential knowledge for the designer who wants to control sunlight. How to use the sun's radiant heat to best advantage as a source of winter heating. How to keep this same heat out of the house in summer when it's just a nuisance.

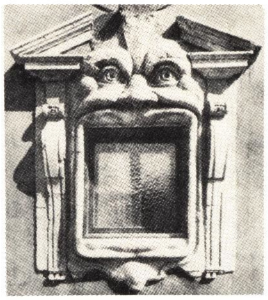




Directions for using the Baker-Funaro SUNFINDER, a new graphic aid which can be used under a tracing of any building plan. An invaluable tool for the design of sunshades, for determining the best position for overhangs and projections, for sun louvers and shade trees. It serves equally well for the placing of single windows or for the orientation of large groups of buildings to best advantage. It will show at a glance the direction and angle of the sun at any time of any day. In addition it will also show the length and direction of shadow cast by any object set in the path of the sun's rays.

CREDITS AND INDEX . . . . pages 143-144

WHY IS A WINDOW?

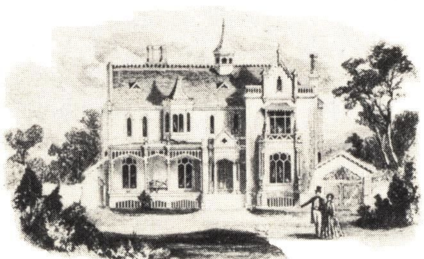


Windows are of all sorts

small and large, wide and tall, regularly and irregularly spaced, in the walls, in the roof, and even in the floor.

They may be left as openings, or closed with some translucent or transparent material to keep out weather and hinder the passage of heat.

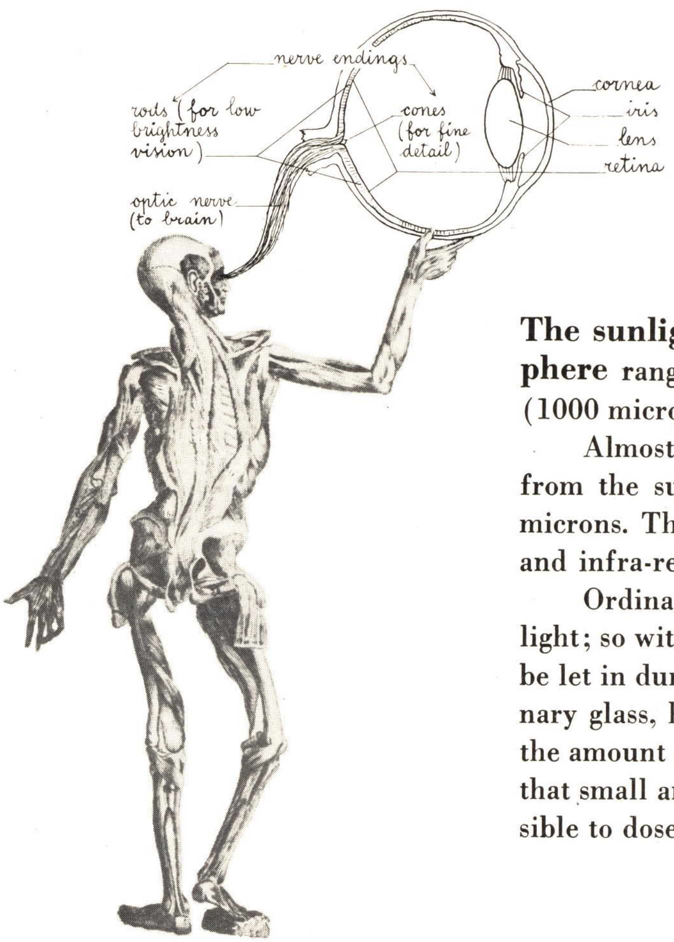
But all of them, without exception, have as their main purpose:



"... at once
picturesque, unusual, and sincere."

TO LET IN DAYLIGHT. But what is daylight? It is a sensation conveyed by nerve fibers from the eye to the brain. It is a subjective sensation; it cannot be measured.

What we can measure is the intensity (brightness) and the wave length (color) of the energy which reaches the eye. The eye judges these mainly by comparison.

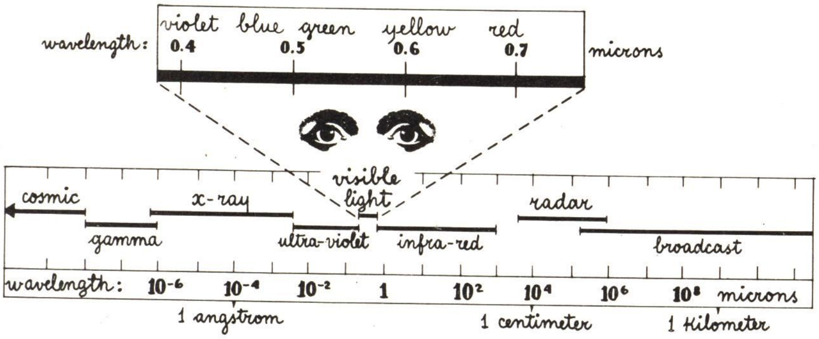


THE HUMAN EYE collects light rays and brings them to focus on the thousands of sensitive nerve ends beneath the retina. This stimulus is translated by the brain into sensations of light, shade, color. In low light the eye becomes more sensitive by developing "visual purple". In bright light the iris contracts and "visual purple" slowly turns yellow. This adaptation cannot be made suddenly.

The sunlight which penetrates the earth's atmosphere ranges in wave length from 0.29 to 2.5 microns. (1000 microns = 1 millimeter)

Almost one half the total radiation which we receive from the sun is in the form of visible light, 0.4 to 0.8 microns. The rest is ultra-violet (shorter in wave length) and infra-red (longer in wave length).

Ordinary glass will let through infra-red just as it does light; so with skillfully placed controls these heat rays can be let in during winter and kept out during summer. Ordinary glass, however, will not let through ultra-violet; but the amount of this necessary for health is so small (though that small amount is essential), that it is usually more sensible to dose with direct sunlight.



The source of daylight—THE SUN is out of man's control.

It is a point source of light, like a very powerful incandescent lamp, with a brightness* of 450,000,000 foot-lamberts. Man can neither move it nor switch it on and off.

The sun never stands still (more exactly, of course, the earth never stands still). Its movement is, however, regular, predictable; but **the intensity of daylight reaching the earth is neither regular nor predictable.**

It is dependent upon the whims of the clouds. On a dull, overcast day with misty rain, the sky will have a brightness of only 400 foot-lamberts. On a clear day with blue sky, brightness will range from 1000 to 2300 ft-L, depending upon the amount of haze.

The greatest sky-brightness will be on a lightly overcast day. Then it will run up to as much as 5000 ft-L, due to the diffusing power of light clouds (more heavily water-laden clouds appear dark). Under these conditions the sun acts as an extended light source, like a fluorescent lamp.

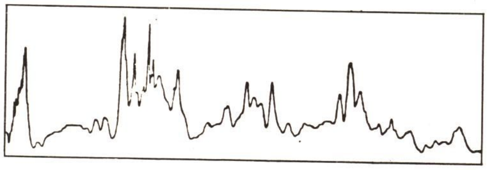
Brighter still, of course, will be objects with high reflection factors exposed to direct sunlight. A white building in direct sunlight, for example, will have a brightness of 8,000 ft-L, which is brighter than even the brightest sky. The important item here is the reflection factor. Trees in direct sunlight register only 320 ft-L.

Except at its source, the sun, **daylight is not visible until it strikes an object.** "Shafts of sunlight" are made visible only by the dust particles within them.

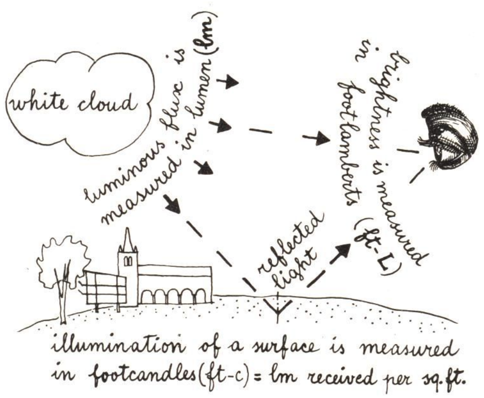
Daylight includes waves of many different wavelengths. Every time it hits an object some portion of these wave lengths are subtracted (usually absorbed by the object which they strike and converted into heat, or in some

THE EYE IS SENSITIVE to only a single "octave" of the waves which travel through the ether. A good radio set has a very much wider range. Invisible rays may be transformed into visible light (i.e. their wavelength changed) by a fluorescent screen.

INTENSITY OF DAYLIGHT is extremely variable. Below is the record of a photoelectric eye exposed to the sky for a few hours on a cloudy day in June.



***BRIGHTNESS** is the measure of the light that strikes the eye. Naturally the light from a small, compact source will seem brighter (and therefore have a higher ft-L reading) than the same amount of light from a more extended source. A surface emitting one lumen per sq. ft. in a given direction has a brightness of one foot lambert in that direction.
The number of foot lamberts is found by multiplying the foot candles of illumination on a surface by its reflection factor.



Brightness contrasts which are above normal ("glare"), and therefore wearying, can be caused just as easily by wide differences between reflection factors as between amounts of illumination. For example, under the same foot-candle illumination, white paper, with a reflection factor of 80%, will appear four times brighter than a piece of cast iron (reflection factor 20%).

TREES can be most efficient sunshades (without necessarily building *inside* them, as shown above). A full-leaved tree will reduce the light falling on a horizontal surface by 75%. By choosing species according to their date of leafing, the period of shading (the extent, unfortunately, with a young tree will change each year) may be planned to fit a particular need. And, unlike calculated shading by a fixed obstruction, it does not have to be for a period symmetrical about June 21.

Below are listed some common species in the order of their coming into leaf. There is a spread of at least two months between the first and the last. Both order and date of leafing will be affected to a small extent by the weather. In southern New England the catalpa will be in full leaf by early June. Early leafers are early shedders, except for the mulberry which sheds early.

Horse chestnut
Willow
Linden
Maple
Elm
Tulip poplar
Beech
Birch
Ailanthus
Ash
Hickory
Oak
Dogwood
Mulberry
Empress tree
Catalpa

cases chemical action), some are reflected in other directions so that our eyes don't receive them.

The light that finally reaches our eyes has had its quality changed. A red object looks red because it absorbs all the wave lengths of white light except the red. The particles of dust and water vapor in our atmosphere, by subtracting certain sections of the sun's light, give the sky its color; and this "incomplete" light is altered once again when it strikes an object and is finally reflected to our eyes.

A white surface is one that reflects all wave lengths equally, it absorbs none (or almost none; 100% reflection is theoretical only). Black absorbs all. Between these two extremes lies the whole range of colors, each of which will subtract from the original light its own particular wave lengths. The amount reflected will range from about 90% in the case of light-colored surfaces, to around 10% in the case of dark-colored ones.

REFLECTION OF INCIDENT LIGHT depends mainly upon the color and texture of the reflecting surface, is less strongly affected by the angle of incidence and color temperature of the light.

	% of incident light reflected
Light cream	80 - 90
Light green, light ivory, light yellow	40 - 50
Browns, olive green, medium blue	10 - 20
Country landscape: grass, trees, etc	10 - 20

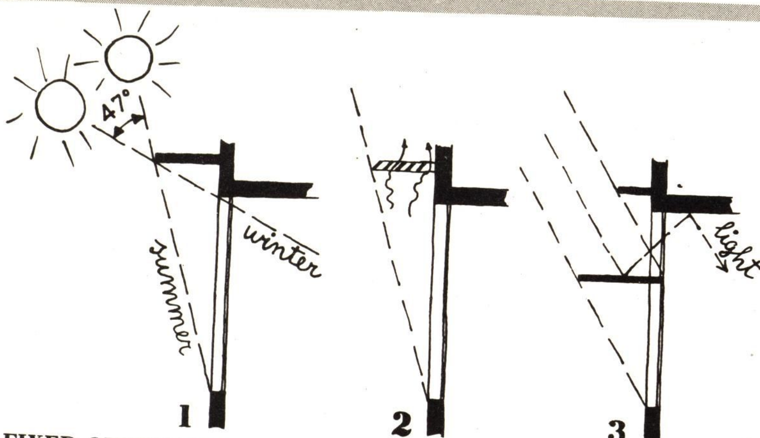
While the source of daylight cannot be controlled, and though even the clouds are still free of man's reaching power, he is able to set up

light controls around buildings and within them. The aim of all such controls will be a more even distribution of light within the building to reduce the high contrast between areas near a window and those further back.

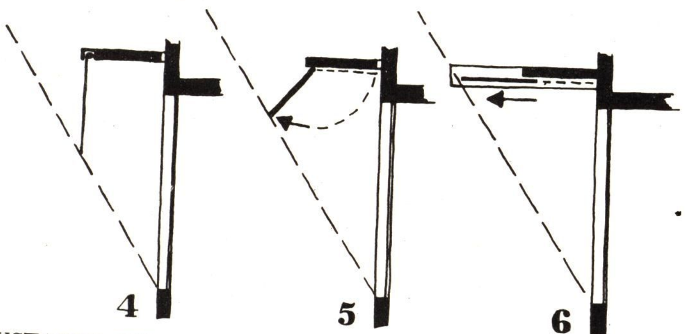
They will be fully effective only if they vary inversely as the light: if a cloud passes across the sun, the shades must adjust immediately. Otherwise they can be used with exact success only for the complete shutting out of daylight. The design of most current sunshades touches haphazardly upon the fringes of the whole complex of light control. On the opposite page are outlined the fundamental devices—almost all custom-made—most widely used.

SUN SHADES

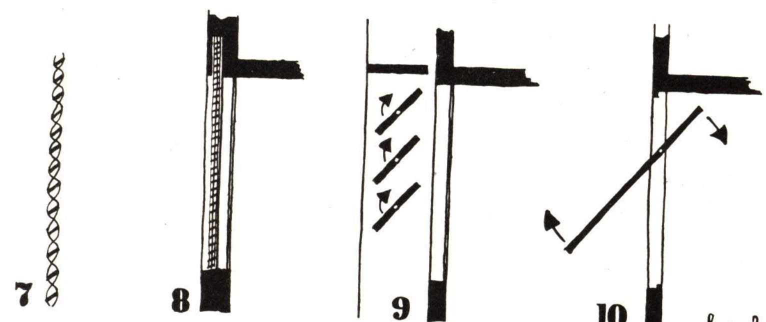
Diagrammatically classified here are some typical built-in sunshades. *Fixed overhangs* must be raised above the window head for full sun penetration in winter. The difference between the sun's altitude at the winter and summer solstices is always 47° anywhere on earth. Improved overhangs slatted, **2**, for air circulation, divided, **3**, to reflect light to ceiling thence to back of room. *Adjustable overhangs* with a roller blind, **4**, a hinged flap, **5**, a sliding flap, **6**. The smallest *horizontal slats* are tiny louvers in an insect screen, **7**. Next is the Venetian blind (metal for outdoors), **8**, then larger slats, **9**, adjusted by hand or photo-electrically according to the changing light. Finally a pivoting (top-hinged if screened) solid wall section, **10**, for use without glass in tropical climates. Where the sun strikes at a very low altitude only *vertical slats* will serve. Sometimes a simple zig-zag of solid and window, **13**, is enough. For air circulation without sun, movable vertical slats must be set apart and wide enough to overlap each other, **12**. The *skylight baffle*, **14**, will be effective only in northern latitudes where the sun's maximum altitude is low (at Viipuri, Finland, it is 53°). A deep-finned *eggcrate baffle*, **15**, will shield unglazed areas from rain and sun.



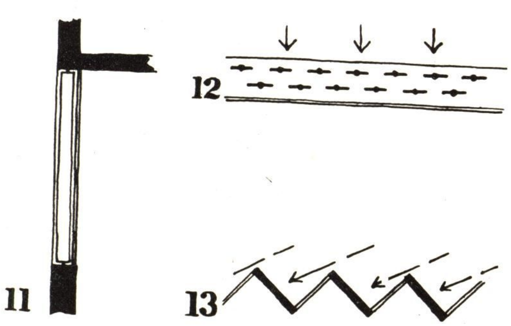
FIXED OVERHANGS



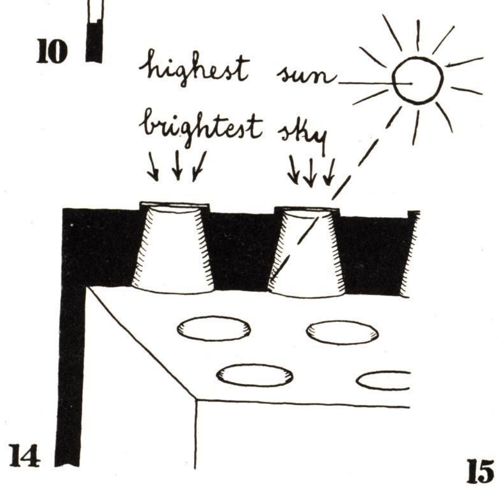
ADJUSTABLE OVERHANGS



HORIZONTAL SLATS



VERTICAL SLATS



SKYLIGHT BAFFLE

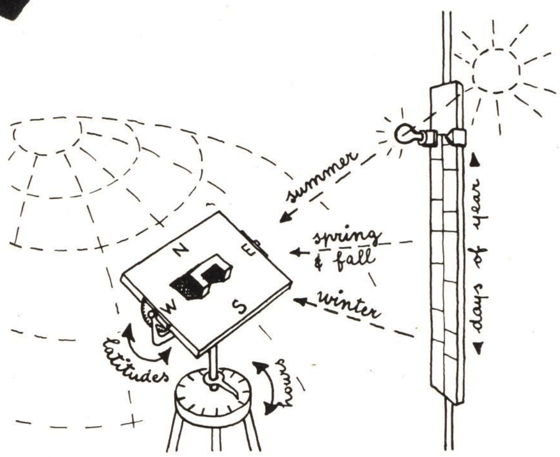
EGGCRATE BAFFLE

CONTROLS FOR DAYLIGHT should affect:

the *amount* of light entering the building;
the *direction* of the light rays, and so their eventual position, their place of striking;
the *quality* of light, its color and degree of diffusion.

There are **three methods of control:**

obstruction of the light rays, blocking them off with opaque shields, absorbing them with black matt reflectors, subtracting some of them with colored glass;
redirection of rays by mirror-bright reflectors, or by channeling them through lenses:
diffusion, by passing the light through translucent materials, or reflecting it from matt surfaces, or a combination of both.



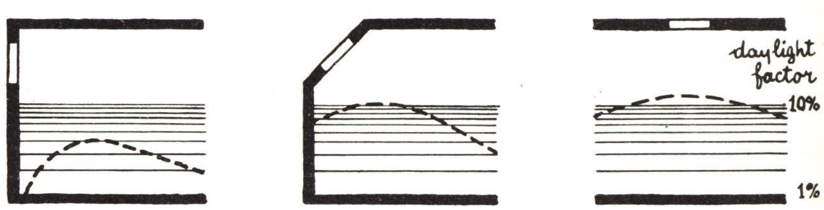
MAN-CONTROLLED SUN AND EARTH—an electric light adjustable for altitude, and an easel adjustable for azimuth (swing) and latitude (tilt)—are used with building models in the Heliodon. It is particularly useful in the layout of large building groups, where its errors of magnification are unimportant.

Where do you want daylight, and when?

This all starts with city planning. The old standard grid plan may be convenient for the buying and selling of real estate, but it is almost certainly not the best layout for the equable sharing and enjoyment of daylight. The placing of windows within a building is secondary to the placing of the building itself in relation to its neighbors.

Position and shape of window openings, the type of glass—clear, diffusing, or directional—the use of baffles, shades and reflectors—all these are intermediate controls between the source of daylight and the area within a building, or between buildings, which is to be lighted.

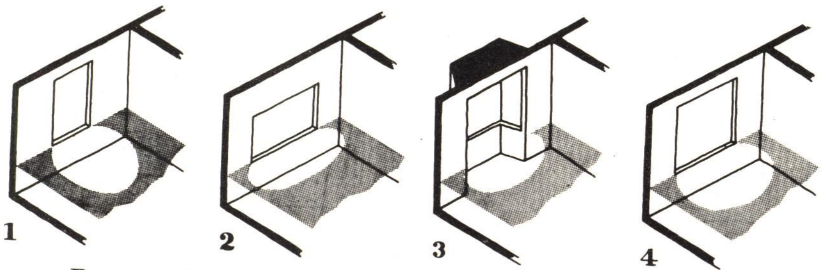
The orientation of a window will determine the amount and type of daylight which it may receive. Its potential may be increased by tilting it toward the sky, so that less light will be lost by reflection off the glass. But then the glass will collect more dirt and, unless washed more often, this will outweigh the saving on reflection.



WHERE TO PUT THE WINDOW, if even light distribution is your aim, is demonstrated in these section-graphs of illumination intensity. They demonstrate a truth which factory designers discovered long since: that for even, high-level illumination, skylights or monitors are far more efficient than side-wall windows. What is not demonstrated is the human demand for view, and the fast, large decrease of efficiency caused by dirt collection on glass, which can quickly cancel out much of the skylights' advantage.

The position of the window opening and its shape—in which must be included any added obstructions such as neighboring buildings, trees, sunshades, etc.—will de-

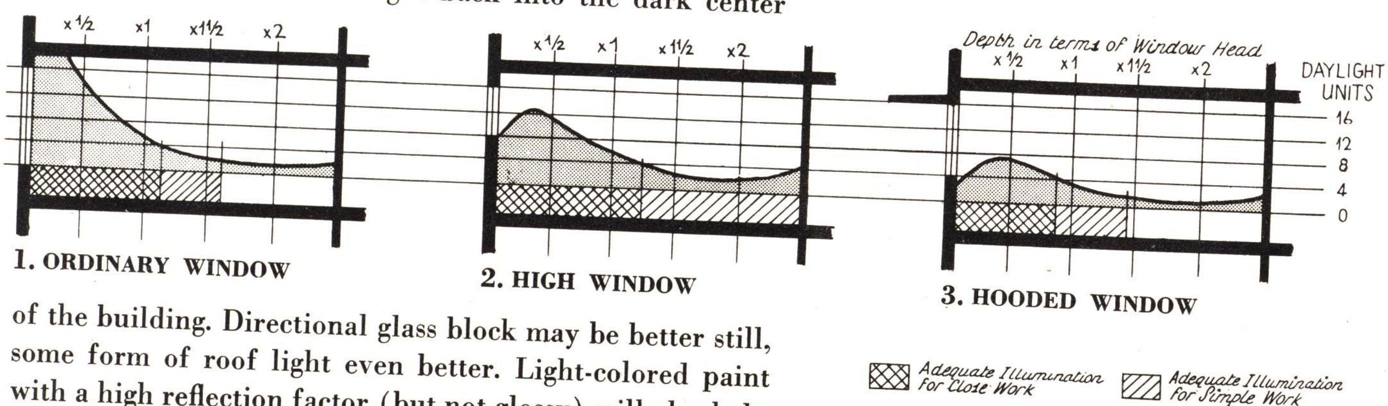
termine the amount and distribution of daylight within the building.



WINDOW SHAPE AFFECTS light distribution as well as view. An oblong window set vertically, **1**, will give a deeper but narrower distribution of light than the same size window set horizontally, **2**. A bay window, **3**, contrary to popular opinion, will give less light within the room than an opening of equal size flush with the wall, **4**, in spite of more glass area.

Bay windows merely increase the depth of the space to be lit; despite their increased glass area, they give less useful light than the same amount of wall opening glazed with a flat window.

The nearer the windows come to the ceiling the further they will throw the light back into the dark center of the building. Directional glass block may be better still, some form of roof light even better. Light-colored paint with a high reflection factor (but not glossy) will also help to spread the light back from the sidewalls.



1. ORDINARY WINDOW **2. HIGH WINDOW** **3. HOODED WINDOW**

EVEN LIGHT DISTRIBUTION is exceedingly difficult in deep rooms lit from one side only. If it is impossible to cut any windows, even a clearstory, in the opposite wall, then raising the sill height, **2**, is probably the least bad solution in most cases. It reduces excessive brightness near the window wall, but has little effect on the intensity further back in the room. Which suggests that the most efficient shading of big window walls would be by blinds raised from the sill. A projecting hood, **3**, will also even the illumination throughout the room, and without sacrifice of view, for the sill may be lower. However, this arrangement reduces the general intensity to such a degree that less than half the room is adequately lighted for close work.
All three windows are of the same area. The sill in **1** is at working level.

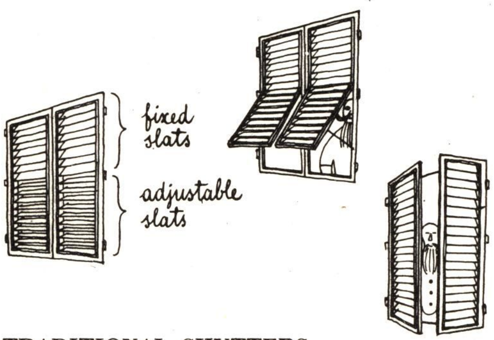
The aim of all these is to even the lighting.

In the design of factories, where these problems have been studied rather intensely, it is found that by using monitors in the roof the maximum illumination is increased very little, but the minimum increases a great deal. Roof lights in other one-story buildings might help to strike an average between too much light near the windows and too little at the center of the building. Large windows far away are less efficient for lighting than small windows nearer; and roof lights have the additional advantage of receiving light from the brightest part of the sky. In overcast weather the sky at the zenith is usually about three times brighter than that at the horizon.

What quality of light do you want?

Direct, intense, warm in color? Or cool, diffused, of low intensity, but widely spread? Even if you know what

THE SPARKLE OF SUNLIGHT delighted not only the meticulous Dutch painters (left), but also the tidy Dutch bourgeoisie marooned in misty damp polders. Contrast of light and shade, however, can become too strong, particularly in drier climates. So there developed that charming diffusing screen of lace (right), with its added merit of one-way vision.



TRADITIONAL SHUTTERS.
Closed (left) they keep out rain and sun, let air circulate. For more air and some view, the lower half opens awning-wise (center). Swung half open (right) the two leaves act as vertical sun shades.

DAYLIGHT FROM HIDDEN SOURCES in a Gothic nave shows the advantage of deep baffles and clearstory windows.

you want, it may not be too easy to decide on the best way of getting it. The art of daylighting is still in its primitive stage where experiment—not precept—shows the route.

First, for the sake of visual comfort, you will probably decide upon trying to reduce the brightness contrasts within the building. An easy and presently popular answer to this (though a not entirely satisfactory one even in theory) is to increase the amount of window area. This usually means that one whole wall will be entirely of glass. This increases the general level of illumination in the room, and so reduces contrast between inside and out, but it may also accentuate the darkness of the other walls.

Just enlarging the hole in the wall is not enough. Even distribution is also necessary.

The best chance for creating a perfectly balanced system of daylighting would be by the complete exclusion of direct sunlight. This is particularly true in the upper stories of high buildings, where there is no light thrown upward from the ground outside to balance the strongly directional light coming in from the sky.

Control would be by reflectors and diffusers, adjustable for position, color and surface texture. Many centuries ago the traditional shutter with movable slats painted green had already arrived at some of the results which lighting engineers now find necessary for comfortable environment.

Whereas in factories and workrooms even lighting is essential, in private houses (were it in fact possible to achieve) such lighting might well be felt dull, flat, uninspiring. The stimulating, warm contrasts of direct sunlight may be quite necessary for human well-being, particularly for the modern indoor-outdoor mode of living. However, the harsh and glaring brightness contrasts that lead to the use of dark glasses, are tiring and painful.

So we should perhaps set up two different environments within the building, one with brightness contrasts not very much lower than those found in Nature on an evenly lit day, the other—further within the house—with lower brightness contrasts. This latter area would have as even and carefully modulated lighting as the vagaries of clouds and sun movement will allow. There will still remain the difficulty of transition from indoors to out and vice versa, due to the slowness with which the eye adapts itself to changing brightness levels.

VIEW is a specialized form of reflected light.

It is usually considered separately from daylight control; perhaps wisely, because it is more often than not in conflict with the devices (louvers, shades, etc.) necessary for such control. View is an emotional desire, light control a set of scientific calculations. When light control demands a clearstory, emotion demands a picture window.

Scientific investigators are doubtless correct in claiming that an occasional distant view is essential for resting the eyes. But it is not as simple as that. What we need is an occasional view of Mr. Abraham's magnolia tree, of that pretty Janet Masters, of Henry Wilson's new Chevvy. We don't complain if some of the sky view is cut. But, unfortunately, for more even illumination (i.e. more light at the back of the room) the sky view should be left open, the interesting part of the view closed off.

Do you want the most extensive possible view by means of glass walls? Or a carefully framed segment of the view in each of a series of windows? A view lit from side and front will be much richer in color and depth than a southern view lit mainly from back and top. And what sill height is best for view?

"There is no subject connected with landscape gardening of more importance . . . than the window through which the landscape is seen . . . There is a circumstance relative to windows which is seldom attended to . . . viz., the situation of the bar, which is too apt to cross the eye, and injure the view, or landscape. This bar ought never to be more than four feet nine inches, nor less than four feet six inches from the floor; so that a person in the middle of the room may be able to see under the bar when sitting, and over it when standing . . . If it can be entirely omitted, the scenery will be improved . . ."*

The window shape may be adjusted to the character of the view—a horizontal window strip for a wide flat landscape, a series of separate vertical panels for a cabin in the forest. Perhaps a time will come when people will not be quite so frightened of a picture window being too small.

A miniature may be just as beautiful as a mural.

At night the beautiful view appears as a black blank, an extravagant light leak. A light-colored shade over the window (the same shade used for light control perhaps) is the best way of restoring the room lighting to normalcy.

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*Humphry Repton, *Fragments on the Theory and Practice of Landscape Gardening*, 1816.

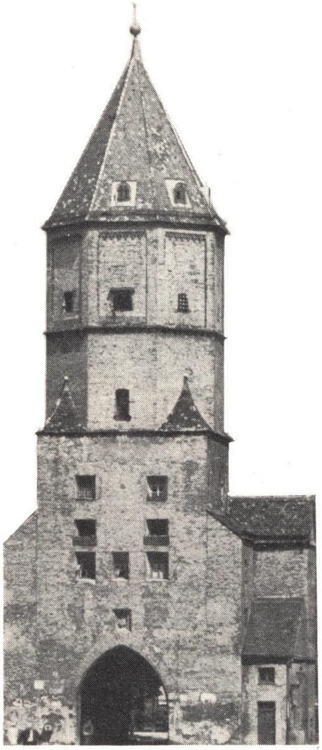
VIEW WAS A PRIVILEGE in medieval Siena, a privilege granted to young as well as old. Children's windows were cut into the walls below or beside the windows used by adults.

FRAMING THE VIEW used to mean excessive contrast between dark wall and brightly lit window (which often prevented the view being seen at all). But the *trompe l'oeil* effect of a missing wall misses also the opportunity of heightening the view's effect by punctuation.

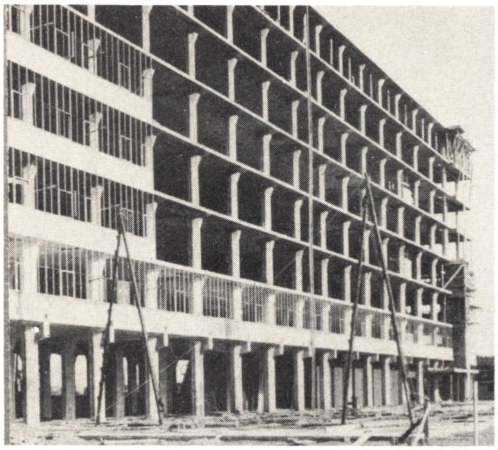
No, not this

But this?

. . . or something else again?



THE SOLID WEIGHT of a masonry wall, laboriously piled together, is emphasized by contrast with small window openings, and deep reveals which fill each opening with black shadow.



THE SKELETAL GRACE of the modern steel and concrete frame building is best analyzed during construction. It can be seen that the skin material, fixed here to the edge of cantilevered floors, has nothing to support except its own weight, wind pressure, and mistreatment by the inhabitants.

And now to consider some of the truths, half-truths, and prejudices—mostly based in history—which tend to becloud judgment and suppress reason in the design of fenestration.

Efficient design of windows and fenestration is still hampered by the lack of clear, comprehensive thinking among the designers, who are in turn hampered by ignorance and half-truths about the basic physical facts of daylighting which we have outlined in the preceding pages.

The designers' outlook is also influenced by their position in the train of history. Which is as it should be; for to forget the past would be as foolish as to ignore the future. Then education leaves further deposits in the mind, until finally each designer has gathered his own little collection of prejudice and anti-prejudice.

This usually coalesces around some or all of these four considerations: windows as façade decoration, the technical complications of making a hole in the wall and finding a durable translucent material with which to fill it, social, political and moral influences, and the window as ventilator.

1. Windows as a façade decoration.

As long as glass-filled windows are used in juxtaposition with solid walls, every building designer worthy of the name will exploit that texture difference to the utmost. It is a legitimate and appropriate way of giving character to his building.

The window is always rightly described and used as a façade decoration.

The walls of the past, being structural, express their massive nature by the contrast between solid and void. Deep reveals lend mystery to the black-appearing glass within the recess of the window. The façade has the depth, texture and strength of a solid.

One can *feel* the weight of that bounding wall. One can imagine the privacy of inside chambers withdrawn from the clamoring world outside.

Now, with modern structural methods based on the use of frame construction,

wall and window are but two textures of the same thin skin.

Structurally neither are of any significance when put

in comparison with the bearing wall. Improved materials are making the skin ever thinner and more efficient.

The pressure of commercial economy for the utmost floor area within a limited and expensive plot causes the skin to be put on the outside face of the frame, or even cantilevered out from it.

The glass exposed on the surface reflects but grayly. It has been stripped of its mystery and dark contrast; it depends now upon its texture, shape and transparency. **Obviously this revolution in materials and structure must be reflected in the facade.** It is one of those indices by which we mark the historic styles.

The van Nelle tobacco factory in Rotterdam, or a house by Marcel Breuer, are just as typically of our age as Raphael's Villa Farnesina is typical of the later Italian Renaissance, or a Norman castle of 12th cent. England.

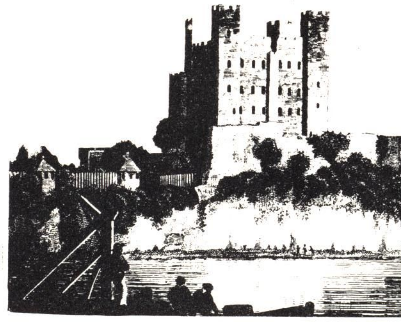
But the designer's approach was different in each case.

The façade of Raphael's villa was designed in conformity with a rigid set of rules governing its style and proportions. These rules were derived from a study of Roman architecture (mostly public buildings which were impossible to imitate exactly because they didn't have chimneys or windows suitable for villas), and commonly accepted by all the leading architects of that period.

The Norman castle was designed primarily to repel enemies. It was what we have become used to calling a **functional** building. The builder built the castle in the style which he thought would most effectively stop arrows, scaling ladders, battering rams. The proportions were governed by anticipated use, not by what the builder thought the Romans might have done.

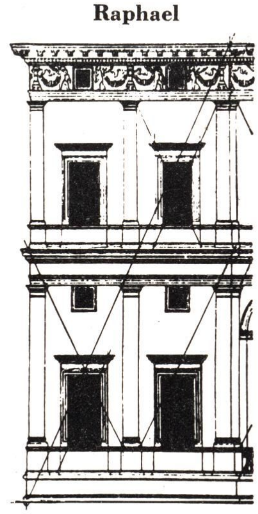
Like the Norman castle, the modern building is free of pre-ordained restrictions (theoretically at least). Raphael was forced to work from the façade to the plan; **the modern architect prides himself on working from the plan to the façade.**

Though modern building does not derive from Vitruvius it very often derives from Mondrian. A conscious, painterly asymmetry is the present vogue, dynamic rather than static balance. This corresponds to the dissolution of the fixed building cube, and the interpenetration of transparent masses which glass, and other newly-developed sheet materials, makes possible.

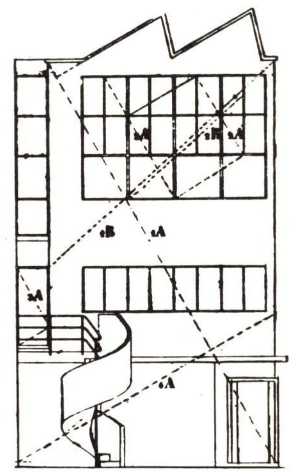


DESIGNED FOR EFFICIENCY, the Norman castle had to repel the symbolic monster at right. The walls were thick and the windows narrow for the same reason that in the van Nelle factory (below) the walls are thin and almost all glass: the designer in each case was trying to design the most efficient and best-looking structure for its purpose.

Raphael

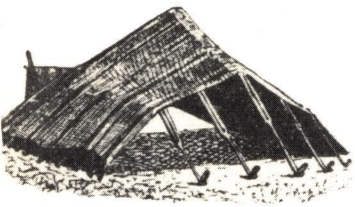


Le Corbusier

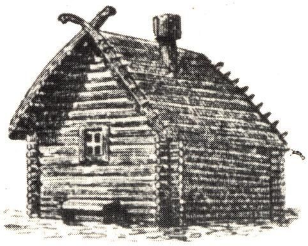


DESIGNED TO CONFORM to a system of proportions. Unlike most modern architects, Le Corbusier, in the Classical tradition, prides himself on following *Traces Régulateurs* (now condensed in the Modulor rule), though these appear justification rather than precept.

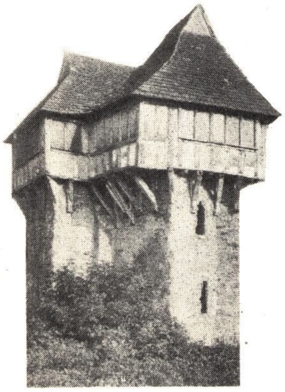
FRAME CONSTRUCTION is indigenous to the U. S. When Capt. John Smith landed in Virginia he found the Indians living in houses of light wood frame covered by sheets of bark and skin; but no glass.



IN THE DESERT, roof and walls in tension; for large, unglazed openings.



IN SIBERIA, large windows discouraged by intense cold, lack of glass.



MEDIEVAL RIBBON WINDOWS blossomed above the thick walls, slit windows, needed for defense. Today large clear glass sheets and steel's high tensile strength make structural mullions, leaded glass lights, anachronistic.

2. The technical complications of making a hole in the wall, and finding a translucent material with which to fill it.

As long as the outer walls of buildings were carrying the load, and the common building materials stone, brick and sod, it was comparatively difficult to make large openings in the walls. And if it were possible to make the hole without danger of the wall's collapse, what material was there which would transmit light yet close the opening against weather and heat loss?

The Eskimos were the only people with a suitable material which was right on the building site and easy to procure. They have been making windows of ice for as long as they have been making their domed igloos. Unfortunately they last only a single winter.

Glass has been manufactured for almost 4,000 years, but it is only since the end of the 19th cent. that it has been available in larger and larger sheets, of good quality, at a comparatively low price. This all traces back to improved manufacturing technique.

When glass was high-cost and low-quality, giving a distorted view even in small pieces, then the small-paned window was reasonable. Its use today is pure affectation, an aesthetic tradition without structural reason for being.

The modern frame building not only makes possible openings of almost unlimited size, it has the additional advantage of putting almost no limits on the disposition of transparent and opaque skin sections. In a bearing wall structure the solids are immovable. In a frame structure with a skin all of glass, light movable screens of some opaque material could take the place of solid wall.

Tradition (often enshrined in the Building Code) is the main reason for such missed opportunities, the lag between invention and fulfilment in use.

However, just because the modern frame building puts almost no limitation on the size and position of clear openings, and just because modern plate glass sheets put almost no limit on size and clear vision, these advantages should not be exploited without due thought and reason. "In many a modern house the use of glass seems to be taken as a point of honor, as an article of faith, so to speak, the credo being to enlarge the area of the window openings to the utmost. Such exaggerations grow only from the wish

to revel in technical novelties, and to boast of the charm of new materials."*

The owners follow close upon their architects' heels in proclaiming the virtues of the fixed window wall, even as they fetch the mop and pail for the condensation, even as they cast a shawl around their shoulders in the evening to protect themselves from the cold which strikes them on the window side. Let us admit it,

many a sweet-looking window wall has gone sour. Even sealed double glazing has a much greater heat loss than a poorly insulated solid wall. Radiant heat coming through the glass from the sun must be anticipated and controlled, if it is to be turned to advantage. Too much daylight, if it increases the brightness contrast, is more likely to cause discomfort than too little. Yet all these possible disadvantages can be turned to advantage by a designer with the necessary knowledge and foresight.

Large windows, provided that they are fitted with adjustable shades, have the same merits as high water pressure or oversized electric wiring: they allow for emergencies—for dull days when you need more light, for sunny days in winter when you need more warmth—even though for all the rest of the time the shades may be partly closed.

LIVING IN A GLASS SHELL in northern latitudes is comforting for tropical plants, but not for humans — without elaborate air conditioning. The visitors to Paxton's Great Exhibition hall were extremely grateful for the shade of the tall elms around which the glass vault had been assembled.

3. Social, political and moral influences.

First it was arrows that we didn't want to let in, then it was the nosey peering of our gossipy neighbors, then we just wanted some place where we could get away from it all without the necessity of joining Paul Gauguin in Tahiti. Then finally we were persuaded that sunshine was more important than any of these (though a few hundred years earlier we had been equally decided that sunshine was very dangerous because it caused decay in the garbage dumps), and now at last we open the walls with glass, even though the glass be fixed shut.

Then, just yesterday, we began to wonder . . .

What had happened to our privacy?

A modern critic*, questioning but not positive, writes of the Tugendhat House by Mies van der Rohe, one of the earliest and most complete expositions of open planning, with glass walls and interpenetrating spaces, one flowing into the other without solid bounding walls ". . . regarding the complete loosening of the walls in the lower floor, one

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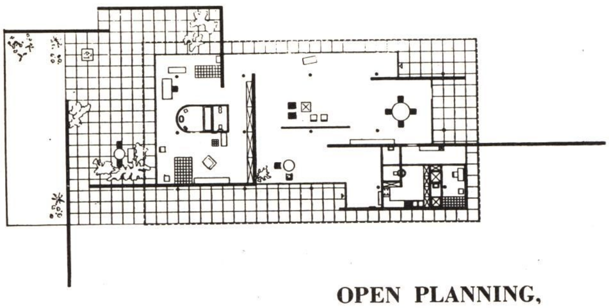
The New Yorker Magazine, Inc.

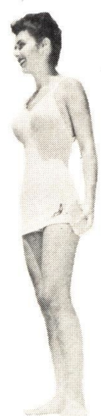
*W. C. Behrendt, *Modern Building*. Harcourt Brace & Co.



OPEN PLANNING, with the architect constructing interpenetrating spaces as the abstract artist would portray them, is most completely accomplished by one of its earliest masters, Mies van der Rohe.

A SINGLE HOLE, at top center of each earth hut, serves as entrance door, window, chimney, fulfills no one of these functions with real efficiency.

has become



EVEN THE HUMAN FIGURE, upon which the Renaissance humanists based their systems of proportion, *has changed*. Our present-day goddess of beauty is taller, slimmer, than a classic Venus.

might doubt whether such an interior can still afford that comfortable feeling of being sheltered which, after all, we are supposed to expect from a house. . . . In former times, space dominated man, and he found his happiness in submitting himself in his own room to the autonomy of its geometric laws. In modern times man dominates space, and consequently he also denies its limits in his own rooms."

The desire for light, like the insatiable desires for liquor and tobacco, has always made window glass a popular object for taxation. In England the window tax, first imposed in 1695, was not repealed until 1845. In the U. S. glass was taxed not only by the local authorities but also by the English king, who prohibited the manufacture of glass in case it might compete with the British exports. As a result small windows were normal among the early Colonial houses. But that is scarcely a good reason for continuing their use today.

4. The window as ventilator

In most primitive houses light percolated through a hole in the roof, where the smoke went out, and through a hole (which could be closed) in the sidewall which served also as a door. Air and light came and went through the same openings, which could be closed with an opaque flap.

When the smoke was led out through a chimney, and window openings, in addition to the door opening, were cut in the walls, it seemed logical to use these same openings for ventilation. For it was not easy to make a weather-tight joint between window and wall, nor between window frame and sash. So there was no inclination to multiply the number of openings.

The Renaissance window, which finally developed from considerations of this sort, is a remarkably ingenious design, particularly as so many functions are combined within this single wall opening. The window is transparent to allow passage of light. There are adjustable openings for ventilation, and there will be some device for controlling light intensity, either blinds, curtains, or louvered shutters. In modern times we have added to this window screens and storm sash, but

it is still proportioned and detailed to fit a facade in the Renaissance tradition of voids and solids. And this is the residential stock window of the catalogs.

It is hardly surprising that many modern architects prefer to use "commercial" windows for the few opening sash which they provide.

The amount of fresh air necessary for healthy ventilation is very small unless there is a cabbage boiling on the stove.

The psychological need for fresh air moving through the room is very much more important.

It is for this reason that the most appreciated openings are those in the center of the wall at the "level of occupancy". For the most effective ventilation the fresh air should be introduced at floor level and allowed to escape at ceiling level, thus harnessing the natural upward movement of the heated air.

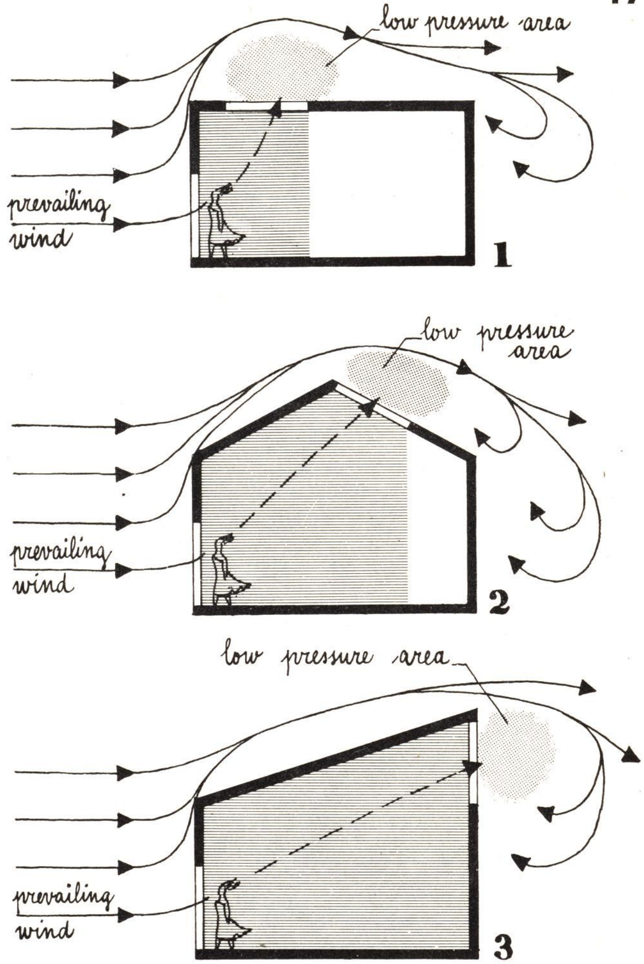
To boost the movement further, orientation is most important, so that the openings will be on the windward side to catch the prevailing breezes. And a commonly disregarded essential is to have an opening to let the air out as well as one to let it in. Inlets and outlets should be of equal area, but the air will be more effectively sucked out if the outlet is placed in the low pressure area which is always formed above or beside the roof.

With central heating systems automatically controlled and supplying specially treated air in controlled amount, it is no longer logical to combine lighting and ventilation as does the opening sash.

Ventilation should logically be combined with heating, and natural lighting correlated with artificial lighting.

For saving wall space in a small room with large windows, or for joy in the feel and smell of fresh air as it comes flooding in the windows, for these the window-ventilator is necessary. And necessary adjunct of the window-ventilator in this country is an insect screen, which reduces incoming daylight by a half, and does even more damage than that to the view. Fixed sash have the great virtue of requiring no screens.

There is no formula here. **Each job must be judged on its own merits, its fenestration decided by a clear, informed mind** without forgetting that thermometers, light meters, and aesthetic canons are nothing more than man-made criteria. They cannot measure subjective sensations, and they are incapable of creation.



NATURAL CIRCULATION OF AIR, "for psychological reasons", should be at the level of occupancy and on the windward side, so that the air's refreshing movement is immediately felt on the face and body. For the greatest air flow per sq. ft. of opening, inlets and outlets should be of equal area; the outlet should be as high as possible above the inlet (so that temperature difference will boost air circulation), and for maximum exhaust effect the outlet should open on to the low pressure area which forms on the roof, **1** and **2**, or at the top of the wall, **3**. Shaded areas are those which have good natural air circulation under the conditions pictured.

Foot lamberts, light intensity, glare?

OPENING SASH : THE BASIC TYPES

CHECK LIST FOR OPENING SASH

The particular requirements of each building will decide which of these features are most important:

Amount and quality of ventilation; possibility of control?

Is the window easily operated?

Weather protection when window is opened?

Weathertightness when closed?

What obstructions to view (rails, muntins)?

First cost? Maintenance costs?

Glass cleaning? Can it be done from inside?

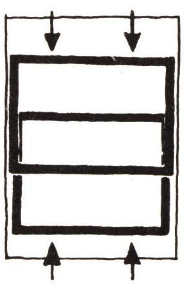
How does the window fit in with plans for screens, storm sash, blinds, etc.?

Opening sash is but a single element in a complete system of fenestration. The reason for an opening sash is to provide ventilation; and so it is called a ventilator, or simply a vent. The relative advantages of one or another type of ventilator can be realistically evaluated only when considered in relation to the complete system of fenestration in which it is to serve. One type of window should not be termed suitable only for certain buildings.

Basically all ventilators either (a) slide on tracks, or (b) swing on pivots or hinges. In some these movements are combined. Those which slide operate on a single plane, but need space beyond the window frame if they are to provide unobstructed opening of the whole window area. Those which swing need three-dimensional space; in return they provide almost unobstructed opening of the whole window area without infringing on the wall space around the window frame.

All the sketches on this and the following page show the windows as seen from outside the building.

SLIDING SASH : VERTICAL



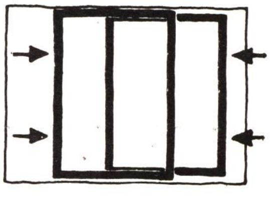
double-hung

The commonest example of this type is the *double-hung* window. It allows very flexible ventilation, and is simple to operate when fitted with good balances (see page 20). It is difficult to clean from the inside; for light sash the best solution is probably to make the sash removable.

There are many other possible varieties of vertical sliding windows beyond the conventional double-hung. A *triple-hung* will increase the size of the clear opening in proportion to the size of the window frame. It will also require less area for stacking than a double-hung, if the need for a completely clear opening demands stacking beyond the window frame.

The sliding tracks may be continued within the thickness of the wall or on one of its faces. They might also be carried up on the ceiling, or behind it, using principles of balanced suspension like the overhead garage door. Even the conventional stock double-hung may be ingeniously adapted to give a clear opening by burying one-half of the complete window in the wall (see page 77).

SLIDING SASH : HORIZONTAL



This has some advantage over the vertically sliding window. It needs no balancing devices and no heavy horizontal bars to interfere with the view. But it does not provide such flexible control of ventilation as the vertically sliding type, and it is much more difficult to make weathertight. Moreover, for easy operation any but the lightest sash require some form of rail and wheel (see page 22). All sliding types can be very easily screened.

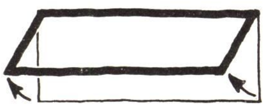
SWINGING SASH : SIDE-HINGED

casement

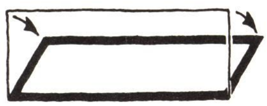
The *casement* can be built to swing in or out. The latter is usually more satisfactory; it gives better weather protection, catches the slightest breeze and deflects it indoors, does not interfere with curtains and shades.

Casements need to be more strongly constructed than sliding sash; being subjected to cantilever strain they have a tendency to warp. Even the outswinging type — practically standard today — can be quite easily cleaned from the inside if fitted with extension hinges.

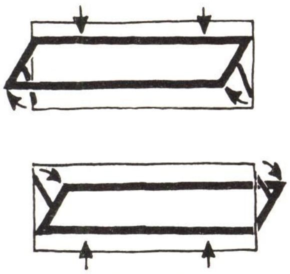
SWINGING SASH: TOP- AND BOTTOM-HINGED



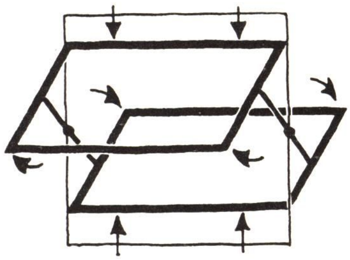
awning



basement



projected



austral

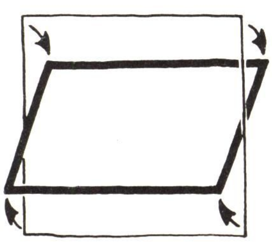
This type of vent may swing in or out. An out-swinging top-hinged sash gives ventilation with awning-like weather protection. An in-swinging bottom-hinged sash, fitted with side shields, gives weather protection and in addition deflects the incoming air upward. The in-swinging vent can be cleaned from the inside.

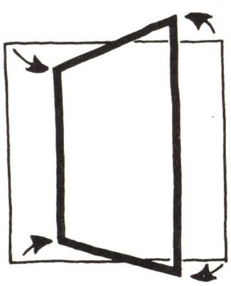
The *projected* sash combines this swinging action with a vertical sliding motion of the pivoting rail. It is easier to operate than the simple swinging type because the swinging and sliding motions are balanced one against the other. This is particularly evident in the large sizes.

A combination of two projected ventilators — an out-swinging one at the top and an in-swinging one at the bottom — is provided by the *Austral* window. A common supporting arm balances the action of top and bottom sash (for details of this hardware see page 25).

Roller shades can be fitted to all top- and bottom-hinged sash so that they provide shade without interfering with the natural circulation of air.

PIVOTED SASH: HORIZONTAL AND VERTICAL

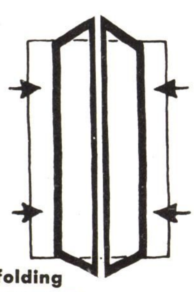




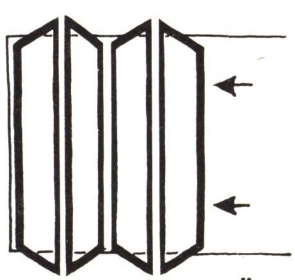
The horizontal pivoted window gives the same advantages in ventilation as the projected window (see above), but it achieves them with simpler hardware (see page 25). Since it swings half in and half out, screening becomes complicated; a split screen or a special protruding cage screen is necessary.

The vertically pivoted window has many of the qualities of a casement, with some added disadvantages. Construction is more difficult, and weathertightness less easily achieved. When open the window protrudes within the building. It is primarily suitable for large sash opened only from time to time for cleaning.

FOLDING SASH



folding casement



accordion

This is the easiest and most economical way to achieve very large, uninterrupted openings (see pages 98 and 99). A cage screen must be built outside unless the windows are to project into the room when folded, thus sterilizing a strip of otherwise usable space. The number of folding joints makes weatherproofing and draught exclusion difficult, particularly in large-scale installations.

In the Browne folding casement window two sashes, operated by scissor-action arms, are hinged to each other down their center edges. This gives better weather protection than the simple casement, and also flue-type ventilation. The view is obstructed by the two sashes standing open right in the center of the window opening.

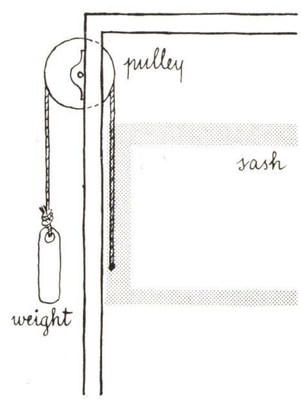
HARDWARE, ACCESSORIES, SUN SHADES

In this section is included the equipment—hinges, locks, balances, etc.—required for the effective operation of opening sash. This equipment can be bought separately or already attached to the sash. The former is still common practice for conventional wood sash (see page 33) and for special custom-made windows.

In most of the mass-produced standard windows the hardware is fitted at the factory, and in an increasingly large number of cases it is made an integral part of the window design. For example, while in conventional double-hung windows the handles for raising the lower sash are separate pieces of hardware attached to the bottom rail, in many aluminum windows a continuous lifting bar is extruded integral with the bottom rail, an obviously neater and more efficient design.

DOUBLE-HUNG WINDOWS

The main problem with vertical sliding sash is how to slide it smoothly up and down without much effort, and hold it at any required intermediate position. This is generally achieved by either (a) counterweights, (b) spring balances, or (c) friction slides.

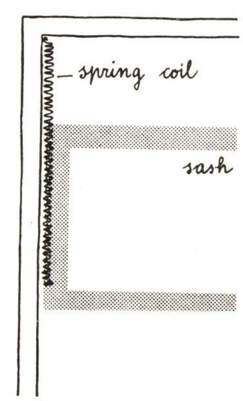


COUNTERWEIGHT BALANCE

Counterweights is the oldest system and still the best one for balance. However, it has some disadvantages. It takes a comparatively long time to install. The counterweights take up space at the jambs and (especially bothersome) at the mullions; and they are often noisy in operation. The window frame must be cut for the pulleys.

Some of these objections have been eliminated by improvements such as roller bearing pulleys and hardwood bushings. Slim weights reduce the space required at the jambs, and overhead pulleys carrying the sash cords all the way across to the jambs eliminate the weights at intermediate mullions. Nevertheless the counterweight type of balance has now been generally superseded, for all but the heaviest sash, by some type of spring balance.

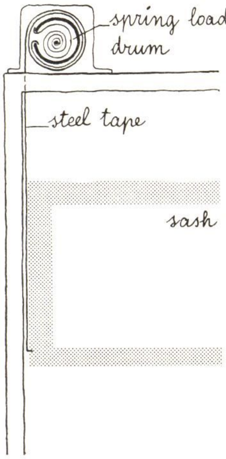
Spring balances employ the action of a spring in tension to balance the weight of the sash. This does not give such an even balancing action as counterweights, for the tension of the spring, and consequently its lifting power changes in intensity with the varying position of the sash. Usually the spring action is supplemented by the friction effect of spring weatherstrips at the jambs.



SPRING COIL BALANCE

Shown here are the three types of spring balance upon which are based most of the available patented types:

1. *Stretching spring coil.* The sash is hung from the jambs on two spring coils, one at each side. A spring cushion friction guide (see page 21) is used to supplement the bal-

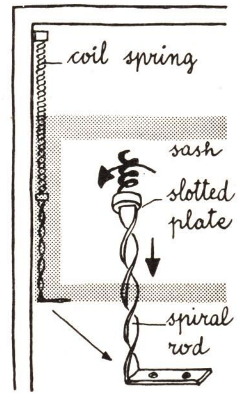


OVERHEAD BALANCE WITH SPRING-LOADED DRUM

ancing effect of the coils. No cutting of the window frame is required. It is usually among the least expensive types.

2. *Spring-loaded drum.* The sash is hung on two steel tapes, one on each side. Each tape is wound on a spring-loaded drum which can be placed above or at the side of the window frame. Space beyond the frame must be allowed for these balances, and the window frame must be cut to accommodate them. This system can be used for quite heavy sash (up to 100 lbs. in weight).

3. *Spiral-wound coil spring.* Two spirally-turned metal rods are fixed to the bottom rail of the sash, one at each side. Each rod passes into a coil spring via a slotted plate fixed across the bottom of the spring. This spring is fixed at the top to the window frame but free to revolve (not to stretch) for the rest of its length.

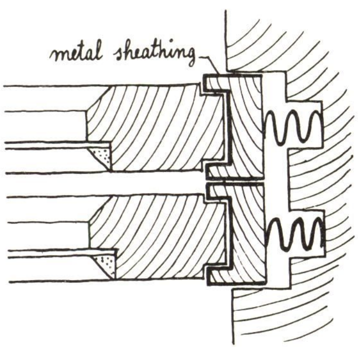


SPIRAL-WOUND SPRING BALANCE

A downward movement of the sash, carrying the spirally-turned rod through the slotted plate at the bottom of the spring, forces the latter to wind in tension. The tendency of the spring to unwind then exerts an upward pull on the spiral rod, thus balancing the sash.

There are many different makes of balance using this principle, each one with some individual variations.

No cutting of the window frame is necessary, though a groove must be plowed in each stile of the sash. With lightweight sash this type of balance may be applied on one side only, using gliders or equalizers on the opposite jamb.

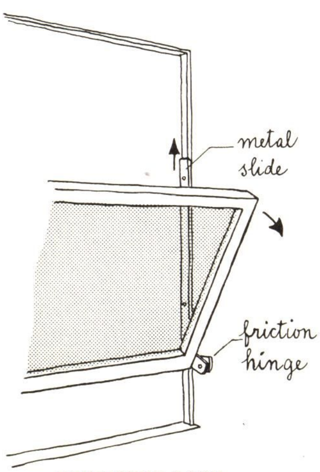


SPRING FRICTION GUIDES

Friction Guides. With light sash balances are unnecessary; friction guides alone are sufficient for easy operation. In the R.O.W. type the guides are sheathed in metal. One of the two guides is fixed, the other kept pressed against the sash by springs housed in the jamb.

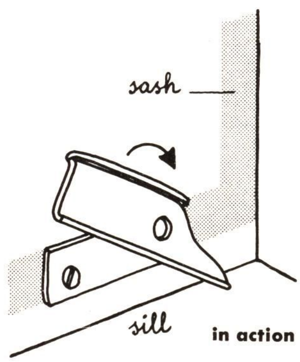
The sash can be easily removed without tools, for window cleaning, or to give a larger clear opening in summer. It is simply pressed against the friction guide until it can be disengaged at the opposite jamb.

Reversible Sash. The difficulty of cleaning the outside face of a double-hung window from inside has brought into being a number of special designs, which combine the normal up-and-down movement of the double-hung with a pivoted or hinged action. The Mauro, for example, (*left*) has metal slides down the side of the sash. These act as frame members when the sash is swung in like a bottom-hinged vent on friction hinges.

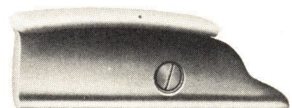


REVERSIBLE SASH

Locks and Handles. The cam-action sweep lock is most generally used. It locks the window closed and pulls the two sash tightly together at the meeting rail. For locking the sash in some intermediate position there are various types of pin and wedge-action fittings.



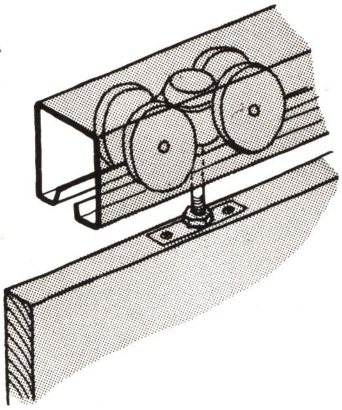
in action

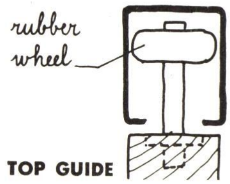


LEVER LIFT HANDLE

For lifting the lower sash, many windows (especially the extruded aluminum types) now have continuous handles which are part of the sash rails (see page 39). For large heavy sash there is a lift handle (Truscon) which acts also as a lever against a plate on the sill. This easily overcomes inertia and the friction caused by weather-stripping, particularly where the handle is hard to reach.

HORIZONTAL SLIDING WINDOWS



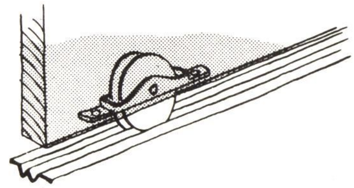


TOP GUIDE

Sliding windows may be operated in one of two ways: (a) by sliding the sash on a track at the sill, or (b) suspending it from hangers which ride along a track at the head. The latter is more suitable for tall, heavy units or in cases where sill tracks must be avoided.

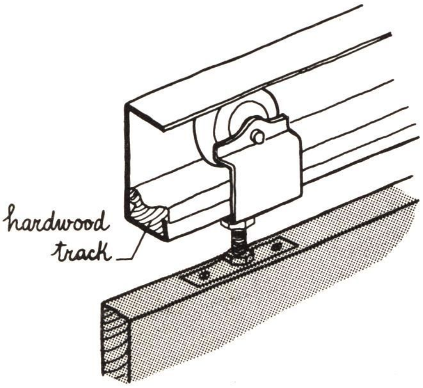
Sill track. A mass-produced standard window of this type is shown on page 36. Two steel glides fastened to the bottom of each sash ride in a groove cut in the hardwood sill. At the head two projecting steel pins sliding in a track act as guides. The sash can be easily removed by lifting it up and disengaging the bottom glides.

For custom-made windows there are metal sheaves, tracks and top guides of many sizes and types.

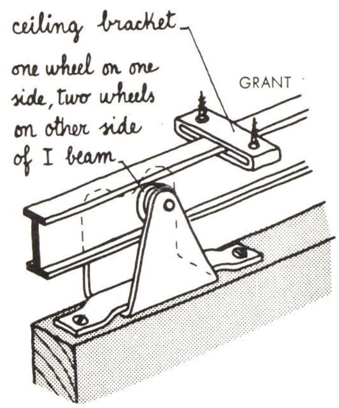


SILK TRACK & SHEAVE

Overhead tracks range from those suitable for a light curtain to those heavyweights made for the doors of airplane hangars. All are based on the same principle: a wheeled truck running on a track. If the truck is fitted with a pivoted hanger the sash, sliding and swinging simultaneously, have an accordion action.



OVERHEAD TRACKS
RICHARDS-WILCOX



GRANT

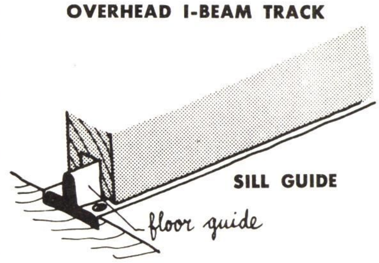
OVERHEAD I-BEAM TRACK

CASEMENT WINDOWS

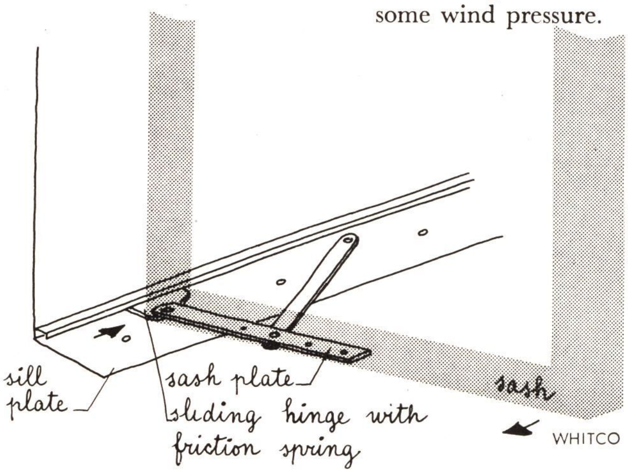
Hinges for casements are of three types: close, extension, and sliding. Most outswinging casements have extension or sliding hinges, as these allow cleaning of the window from the inside.

The sliding hinge has a scissor action. The sash is hinged to sliding shoes which move along tracks at head and sill. The swing of the sash is controlled by two arms, which are hinged at one end to the sash, at the other to the window frame. This type of hinge has all the advantages of the extension hinge and in addition it gives the sash better support.

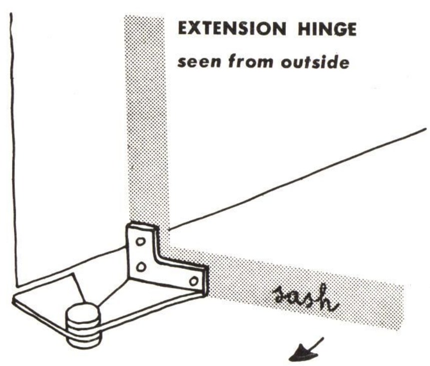
Hinges may be of free or friction type. The free hinges are used when there is an operator (see below) to hold the sash fixed open. Friction hinges do away with the need for an operator. They are loose enough to allow opening and closing of the sash, but also stiff enough to withstand some wind pressure.



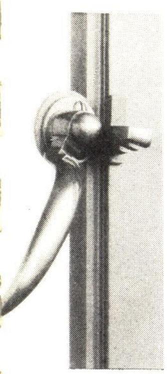
SILL GUIDE



WHITCO

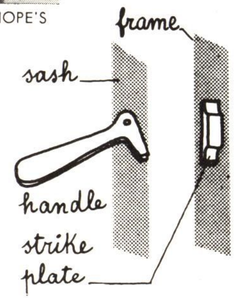


EXTENSION HINGE
seen from outside



SIMPLEX HANDLE WITH ADJUSTING NOTCHES

HOPE'S



Handles. The "Simplex" type is attached to the sash and is used, like a door knob, both for operating and locking. If a screen is used the handle is reached through a wicket.

The roto-type handle is attached to the window frame or to a mullion. It engages, through a slot, with a keeper on the sash. It is especially designed for use with a fixed screen. When used (as normally) with an operator no wicket in the screen is needed.

Operators are used to open and close the sash and hold it at any intermediate position without the use of friction hinges. The simplest types are stay bars which can be held in various positions by notches or set screws. These have the disadvantage of protruding inside when in an intermediate position between full open and closed.

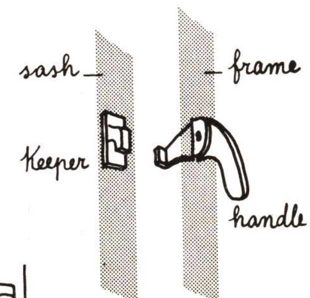
Far more efficient, and the only type of operator in common use today in the U. S., is the roto operator with worm gear. This operates a projecting arm which slides along the bottom of the sash. A simpler type, called a lever adjuster, replaces the worm gear with a lever arm, is otherwise identical with the roto operator.

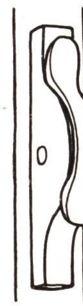
In wood casements, to supplement the action of the operator, a top closer is often fitted. This is a spring catch which pulls the top of the sash tightly closed against the frame, to counteract any warping.

The Hartman window is a new type with casement action governed by a roto operator acting directly on the hinged stile, instead of through a sliding bar on the bottom rail; this, combined with offset hinges, allows the sash to be opened a full 180°. Both framing and hinging of this Hartman sash are of unconventional type. The conventional rigid frame of opening sash is replaced by a narrow molded rubber edging of the glass. Support is by a C-shaped hinge member extending half way along the top and bottom edges of this sash and attached to it—at the two hinge extremities only—by pivots. Thus the sash will both hinge and pivot, giving a wide variety of possible openings and easy cleaning of its outside face.

PAIR OF ROTO-TYPE HANDLES AT MEETING RAIL

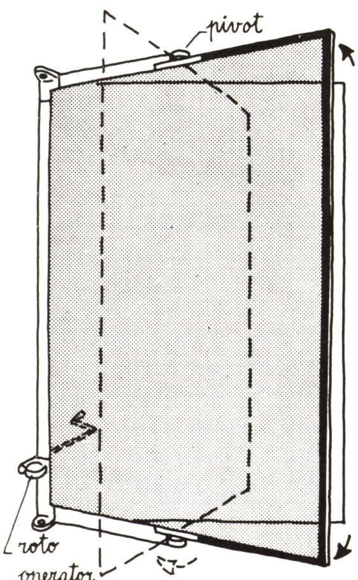
HOPE'S



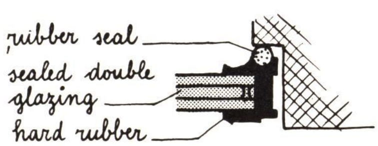


ROTO-TYPE THUMB LATCH

THORN

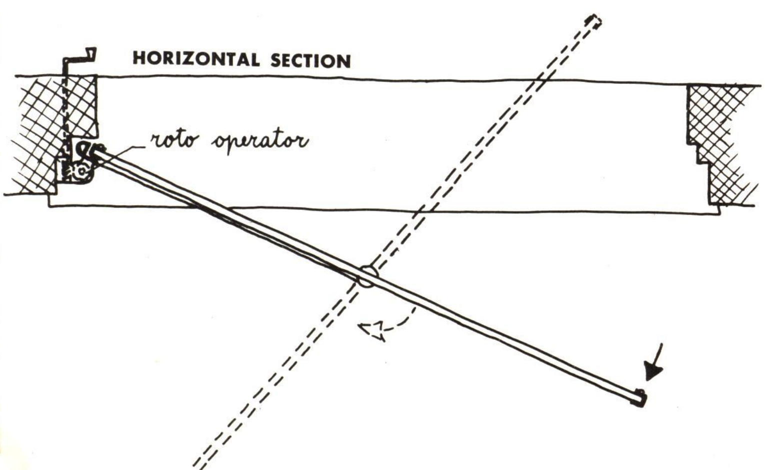


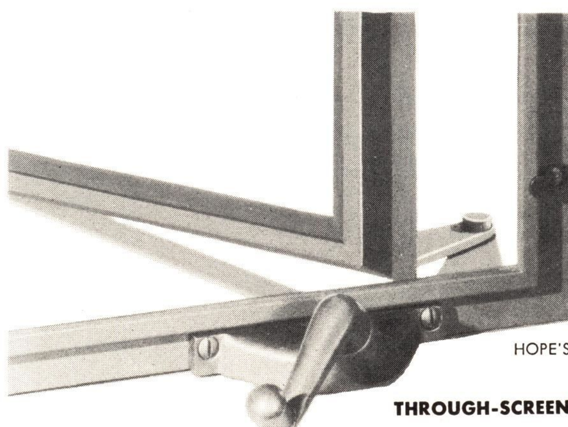
HARTMAN WINDOW



GLASS SURROUND DETAIL

HORIZONTAL SECTION

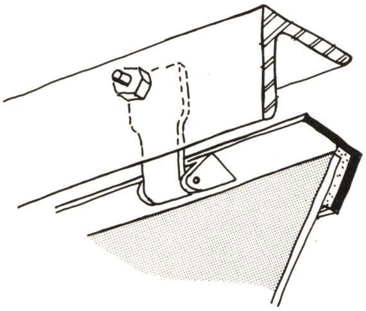




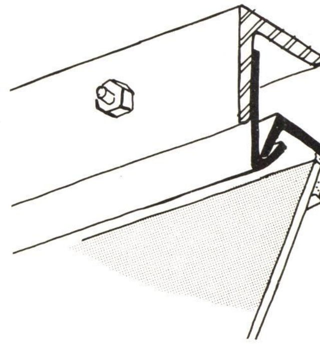
HOPE'S

THROUGH-SCREEN ROTO OPERATOR

TOP- & BOTTOM-HINGED WINDOWS



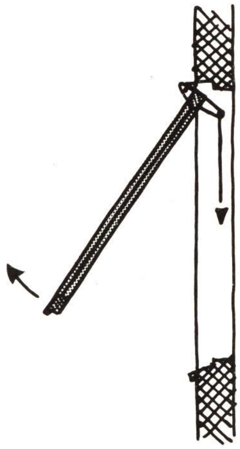
HINGE FOR CONTINUOUS INDUSTRIAL WINDOW



CONTINUOUS HINGE

Hinges. All the standard varieties of hinge are used, and in addition two special types, the continuous hinge and the side hinge. The former is for top-hung sash. A continuous flange of the top rail hooks over a ledge on the window frame (Truscon). It is successfully used for Continuous windows (see also page 43).

In a side hinge, steel pins extending beyond the ends of the top rail (if top-hung), or the bottom rail (if bottom-hung), are supported by brackets attached to the frame. This type of hinge is useful for light sash which needs to be frequently removed from the frame or replaced by screens (e.g., the so-called Basement window). It is also used in Awning windows, where the absence of fixed horizontal bars between the vents precludes the use of any other type of hinge.



TOP-HINGED (AWNING) WINDOW WITH LEVER ARM

Operators. Top- and bottom-hinged windows require operators not only for opening and closing but also to hold them against gravity in any intermediate position. For out-swinging sash through-screen operators will normally be used.

There are two ways of operating top-hinged sash: by push bar or by lever arm. The push bar, hinged to the stile or the bottom rail of the sash, usually slides through a slot in the frame, and can be locked in any position. The lever arm, on the other hand, is rigidly attached to the top rail of the sash. Rotation of this top rail by the lever arm opens and closes the sash.

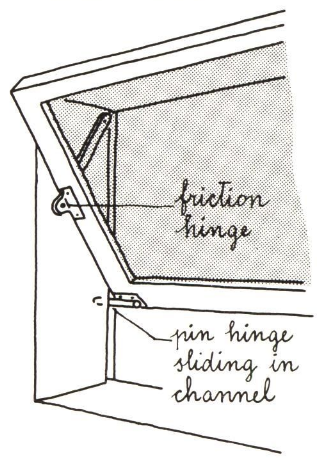
The push bar gives more support to the sash than the lever arm, so it is used in everything from the lightest vent to the heaviest continuous windows. It can be operated by hand or by a mechanical operator (see page 26).

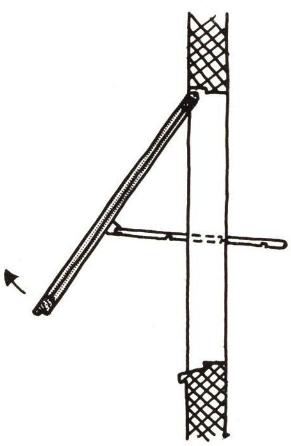
The lever arm is particularly useful for light sash which are too high to be reached directly; and it is extensively used for batteries of light Awning windows.

Bottom-hinged sash are kept open by arms or straps. For large, heavy sash these may be mechanically operated.

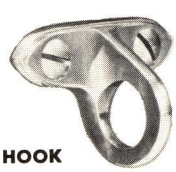
Locks and Handles include several types of spring-loaded catch for operation by pole or chain. For more accessible sash a "Simplex" type of handle (see page 23) is commonly used.

BASEMENT WINDOW

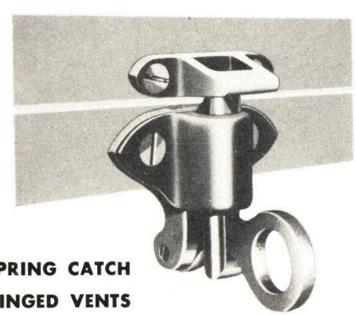




TOP-HINGED (AWNING) WINDOW WITH PUSH BAR

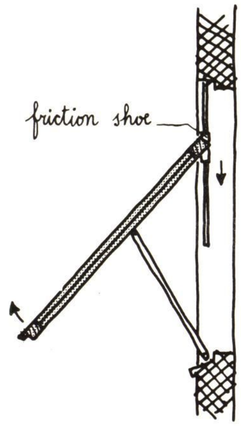


POLE HOOK



SPRING CATCH FOR BOTTOM-HINGED VENTS

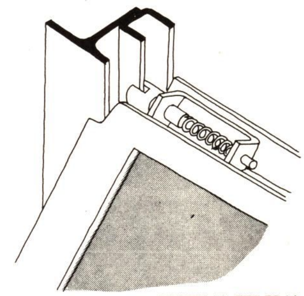
PROJECTED WINDOWS



PROJECTED WINDOW

Hinges for Projected windows are of the sliding type already described under Casement windows (page 22), but used vertically instead of horizontally. Pivots at the end of the top rail (for out-projecting sash) or the bottom rail (for in-projecting sash) are set in friction shoes which slide vertically along tracks in the window frame (in metal projected windows the frame doubles as track). The friction of these shoes—usually by a spring—must be sufficient to hold the window open at any point against gravity, yet the shoe must be loose enough to allow easy operation.

The swing of the sash is controlled by the side arms. These are hinged to the sash and the frame and carry most of the weight of the sash.

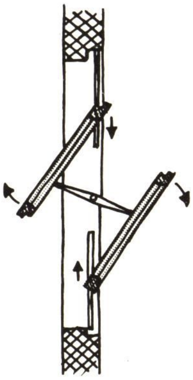


CRITTALL-FEDERAL

FRICTION SHOE FOR COMMERCIAL PROJECTED WINDOWS

Operators. Due to the friction shoes, Projected windows will remain at any opening position without the use of a stay bar. A "Simplex" type of handle (see page 23), combining lock and operator, is therefore used.

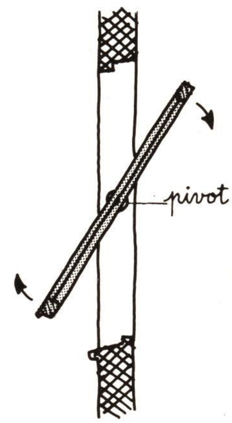
AUSTRAL WINDOWS



AUSTRAL WINDOW

As the Austral window is nothing more than an out-projecting sash balanced against an in-projecting sash by common side arms (called balance arms), its hardware is similar to that of the projected window. However, no friction shoes are required, as one sash balances the other.

Guide pins, on which the sash pivots, slide along grooves in the jambs. These guide pins, the balance arms, and a lock at the meeting rail is all the hardware required.

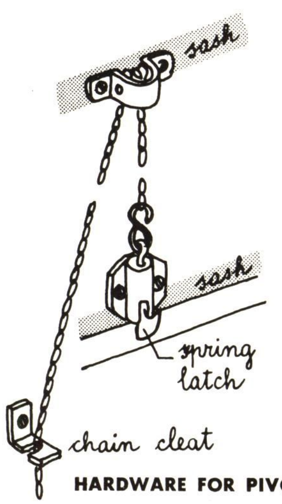


PIVOTED WINDOW

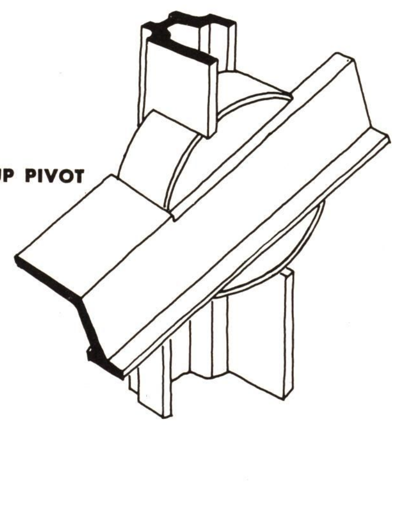
PIVOTED WINDOWS

There are two types of pivot in use for these windows. The first is a simple hinge, the second is a pair of bronze cups, one attached to the sash, one to the frame, and sleeved one over the other. If these are properly fitted they will give better weather protection than the simple hinge.

Locks and Handles. Spring-loaded catches operated by chain or cord combine locking and operating of pivoted windows at a distance. For those which are accessible a notched stay bar is commonly used.

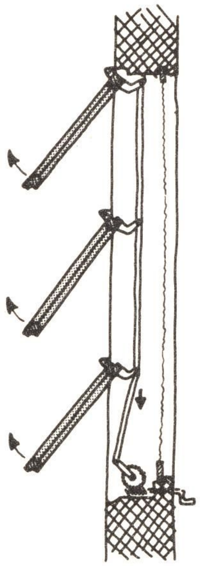


HARDWARE FOR PIVOTED WINDOWS

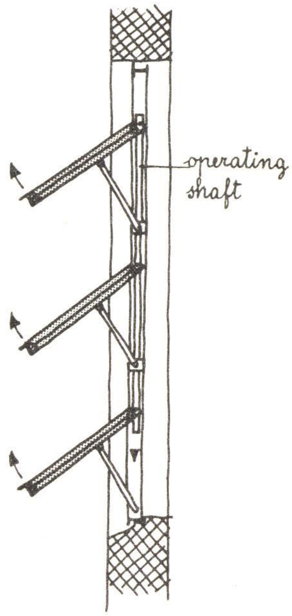


BRONZE CUP PIVOT

MULTIPLE OPERATORS



BATTERY OF AWNING WINDOWS WITH ROTO OPERATOR



BATTERY OF PROJECTED WINDOWS

These can be used for all types of swinging sash—side-hinged, top- and bottom-hinged, Projected. Each sash is connected by some form of arm to a common shaft. This shaft in some types of operator revolves, in others it moves lengthwise. In order to hold the sash open against gravity, there must be some gearing or notches to hold the shaft fixed in any desired position.

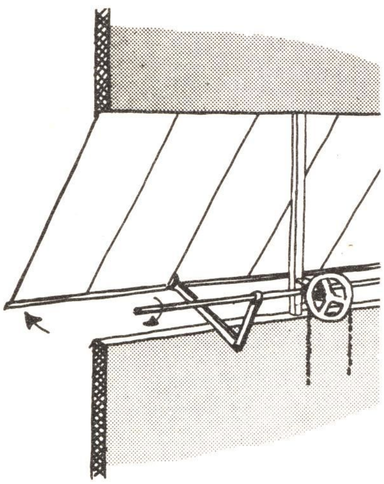
An exception to this last is the Projected window which, because of its balanced action, will stay put in any position without being held. So for a vertical battery of Projected windows it is only necessary to connect the friction shoes with a vertical shaft, whereupon the operation of one sash will cause a simultaneous operation of all others in the battery.

As a further refinement, in the Donovan system the bottom sash of such a battery can be disengaged and operated independently, after guiding the upper vents into the required open position.

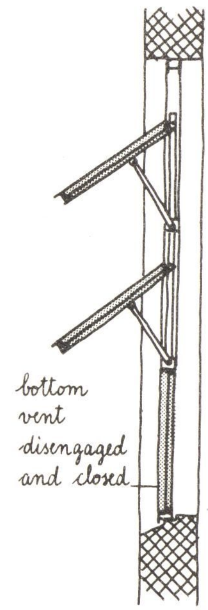
For all other types of swinging sash the main connecting shaft must be held fixed by an operator against gravity. For light awning windows in a vertical battery, a lever arm at each end of the top rail of each vent is connected to a vertically sliding shaft in the jamb. The two shafts are connected by gearing to a roto operator in the sill, which holds them fixed as needed. For heavier sash and longer runs (particularly horizontal) a heavier grade of equipment is necessary. The long connecting shaft may still move lengthwise — the tension operator — as in the awning window equipment just described, or it may revolve—the lever arm and rack-and-pinion operators. It may be hand- or motor-operated, according to conditions.

For long horizontal runs (up to 300 ft.) the tension operator is most common. A horizontal shaft moving laterally is connected to the sash by lever or scissor-action arms. This same type of mechanism is also used for operating a series of short Continuous windows set in a battery one above the other in a tall opening.

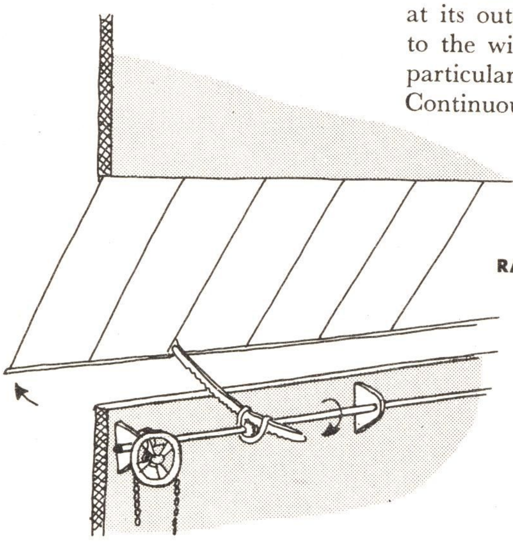
In the rack-and-pinion operator a gear wheel on the revolving shaft engages with a toothed bar attached to the bottom rail of the window. In the lever arm operator a bar fixed to the revolving shaft at right angles is hinged at its outer end to another bar which in turn is hinged to the window. This results in a jack knife action. It is particularly suitable for quick operation of short runs of Continuous windows where strong leverage is unnecessary.



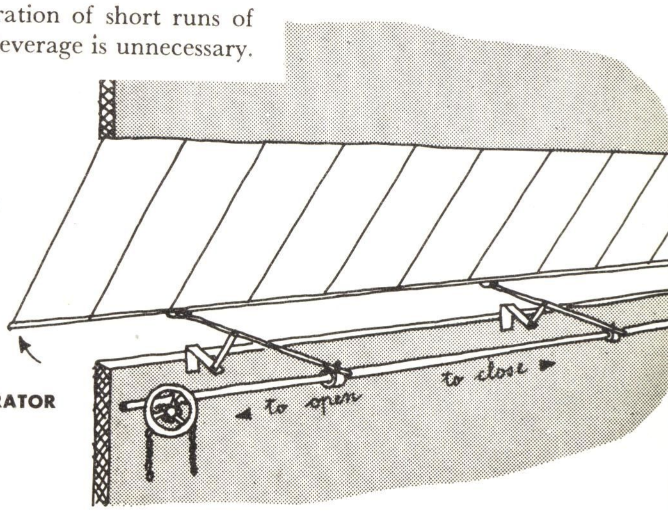
LEVER ARM OPERATOR



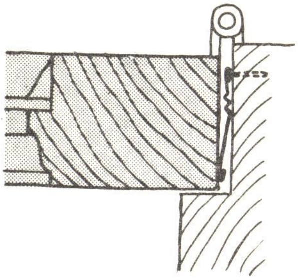
BATTERY WITH DONOVAN CONTROL



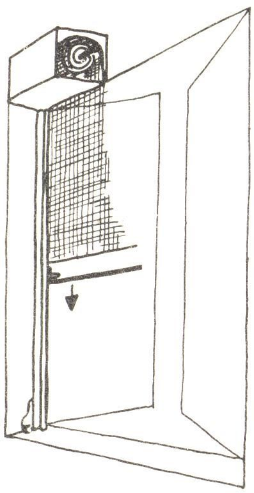
RACK AND PINION OPERATOR



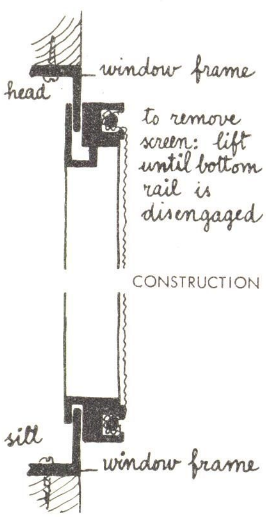
TENSION OPERATOR



SPRING CONTACT METAL WEATHERSTRIP



OVERHEAD ROLL SCREEN
ROLSCREEN



CONSTRUCTION PRODS.

SCREEN PANEL HELD BY SLOT INTEGRAL WITH WINDOW FRAME

WEATHERSTRIPPING

The purpose of weatherstripping is to seal the joint between an opening sash and its frame. All sliding windows need some type of weatherstripping to prevent air leakage. In wood windows its resiliency allows the wood to expand and contract without jamming the sash.

In all mass-produced standard windows weatherstripping is made an integral part of the window (see pages 32-37). For the conventional wood window. and for custom-made sash, standard weatherstrip by the foot is used.

Weatherstrips may be of metal, rubber, plastics, felt, etc. Metal strips are of two types: interlocking (especially for double-hung windows), and spring contact (used mostly for casements and top-hinged sash.

SCREENS AND STORM SASH

Insect screens and storm sash are regular standard window accessories sold ready for installation.

Screens are of 16 or 18 mesh cloth which may be woven of galvanized steel, bronze, aluminum or plastic. This cloth is either stretched on a rigid perimeter frame—held by nails and a cover mold, or by a metal spline in a spring channel—or wound on a roller like a roll shade.

A satisfactory screen will allow normal operation of the window, will be easily applied and removed from the inside, and stored in a small protected space adjacent to the window. The roll screen alone satisfies these requirements, but in many standard windows it is difficult and expensive to apply.

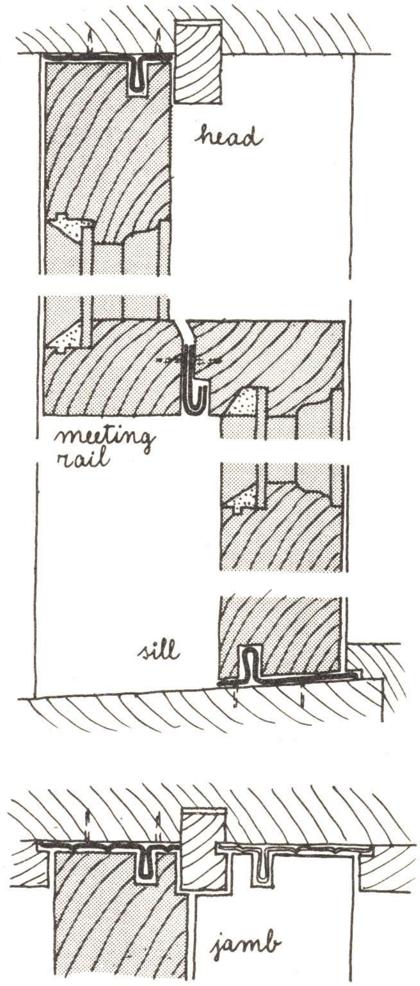
When the normal framed screen is used for sliding or inswinging windows it is usually on the outside, hung by the top edge, and held in place by clips. For out-swinging windows the screen is hung inside and the operation of the sash is by through-screen operators or through a wicket in the screen. For pivoted windows the screen has to be split in half, one half being fixed outside the line of the sash, the other inside.

For a combination screen and sunshade see page 29.

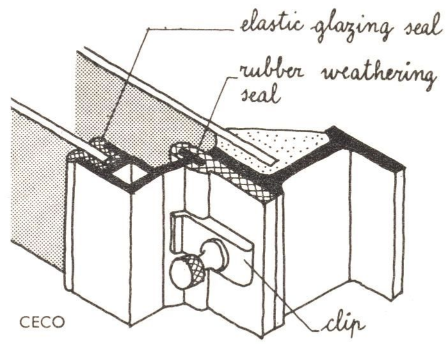
Storm sash is an additional sash added to the outside or the inside of the window during the winter months. Its purpose is to reduce air leakage between the opening sash and its frame, to reduce heat loss through the glass—and so reduce condensation — by creating an insulating buffer space of still air, and in metal windows to reduce the heat loss through the frame also. The result of all this on the inhabitants is lower heating costs and more comfort.

The same results could be achieved in wood sash by sealed double glazing and good weatherstripping. In metal sash, because of the high heat conductivity of the metal frame, a storm sash which covers the whole window, including the frame, will give better results than sealed double glazing.

Storm sash is of the same construction as any other

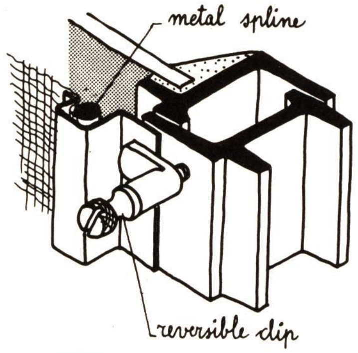


INTERLOCKING METAL WEATHERSTRIP FOR A DOUBLE-HUNG WINDOW

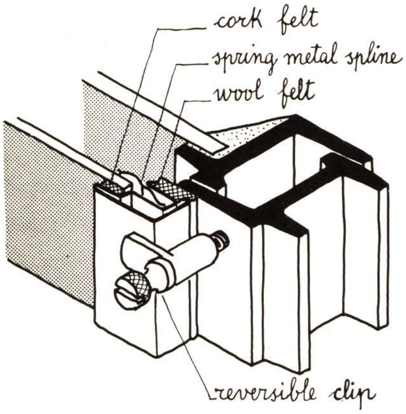


CECO

STORM SASH WITH RUBBER SURROUND



SCREEN IN PLACE



STORM SASH IN PLACE

INTERCHANGEABLE SCREENS AND STORM SASH

light sash. Some part of it is usually designed to open for ventilation. It is usually made interchangeable with the standard framed screens, and held in place by the same hangers and clips. If a metal-framed storm sash is attached to a metal-framed window there should be some insulating gasket between the two frames to reduce the danger of condensation at that point.

Combination screen and storm sash, built within a single frame and ready for attachment to conventional double-hung windows, have recently become popular. Most of such units contain a double-hung storm sash and a vertically sliding half screen. So, when attached to the outside of a double-hung window, there is a total thickness of five vertically sliding panels, four glazed, one screened, all operating independently.

The main advantages of such units are the great flexibility of screened and protected ventilation which they offer (there are 32 different sash arrangements possible), and the elimination of storage and change-over troubles, as screen and storm sash are both permanently attached.

The main objection to such combination units is their cumbersome design, with too many horizontal bars and too many layers of not too transparent material. This may be overcome by taking out and storing elsewhere the screen or the storm sash not in use, but in that case most of the original advantages of such units disappear.

SUN SHADES

The general principles underlying the control of light are discussed on pages 131-140. Tacking on sun shades is not an effective substitute for that basic design and orientation of the building which light control implies. So this brief survey of available shading equipment is intended as information, not prescription.

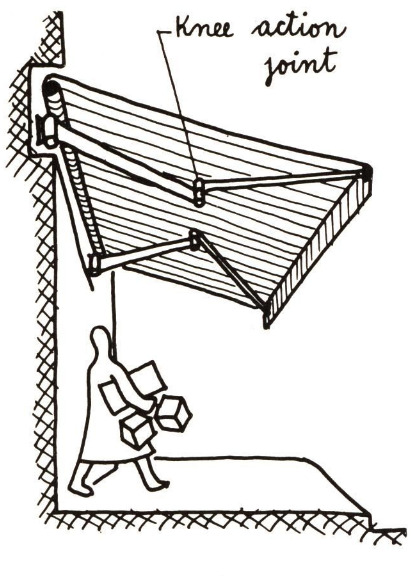
Sun shades may be set outside or inside the window. In both positions they control the light entering the building, but only those on the outside can effectively control the sun's heat. Outside shades must be of durable material to withstand the weather; awnings of interlocking aluminum slats have the advantage over traditional canvas. Left in its natural finish aluminum has the additional advantage of blocking off sun heat by reflection.

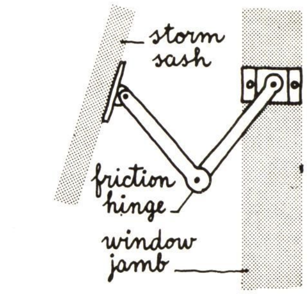
The mechanics of the awning have now been improved so that the supporting arms when extended stay close up under the awning; and when retracted, by use of knee-action joints, they are entirely concealed within the box or recess which houses the awning.

As a sunshade the awning has the advantage of casting an extensive shadow, even with low sun, and being easily rolled up out of the way when not needed. It cuts off all view of the sky, so that the amount of daylight entering the building may be insufficient for some types of work. There is always a clear view out below the awning.

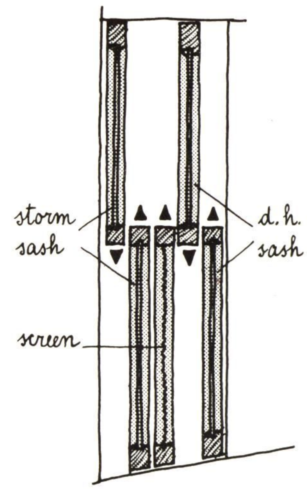
All louver shades, such as jalousies and Venetian blinds,

AWNING WITH KNEE ACTION SUPPORT

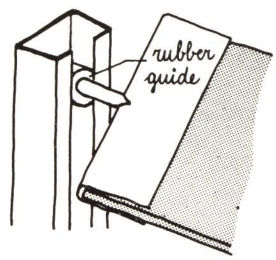




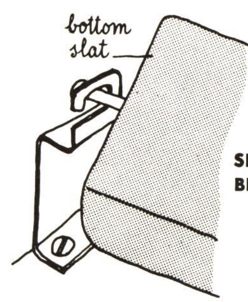
FRICTION HINGE ADJUSTER FOR TOP-HUNG STORM SASH



COMBINATION SCREEN AND STORM SASH FOR DOUBLE-HUNG WINDOWS

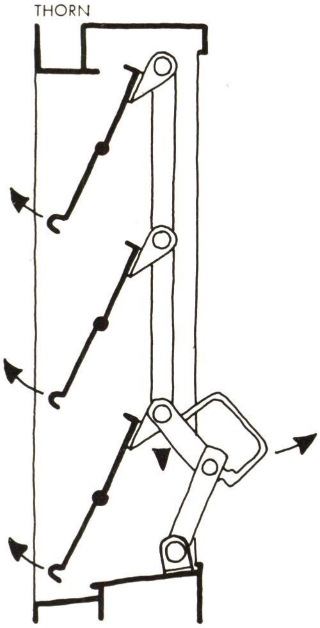


RUBBER-TIPPED GUIDE PIN

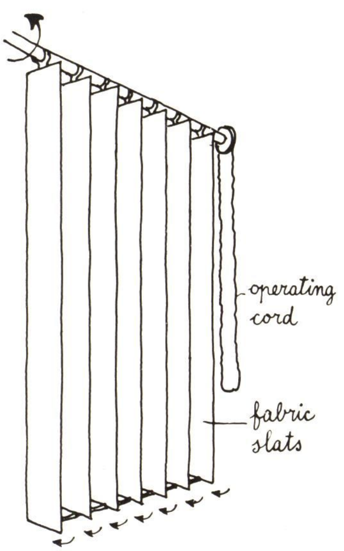


SILL BRACKET

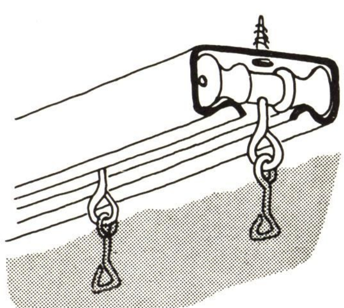
VENETIAN BLIND ACCESSORIES



ALUMINUM JALOUSIE
WITH INTERLOCKING SLATS



VERTICAL VENETIAN BLIND
WITH FABRIC SLATS



TUBE CURTAIN TRACK

give excellent light control (particularly when the louvers are adjustable) but at the expense of view. The least bothersome in this latter respect is a combination of insect screen and fixed louvers. This metal mesh material has the horizontals flattened to form narrow louvers set at an angle of 17° to the horizontal. This will be satisfactory except when the sun is quite low. The material is treated like ordinary screen cloth, mounted on a standard removable screen unit. (Koolshade).

An adjustable jalousie mounted like an awning (Rusco) adds to the latter's advantages a much more flexible control of light. But it has the serious disadvantage of not being easily removable. A horizontal pivoted window of Swedish provenance has sunshade slats set between the double glazing. (Perspective Windows, Inc.).

Sunshades set inside the window, not having to survive any weathering beyond the fading effect of sunlight, may be of almost any material, translucent, solid, or louvered. The only type attached to the sash itself and moving with it is the roll shade, which may be fixed to roll upward or downward. When attached to a movable sash (normally feasible with swinging sash) there is no danger of the shade interfering with ventilation.

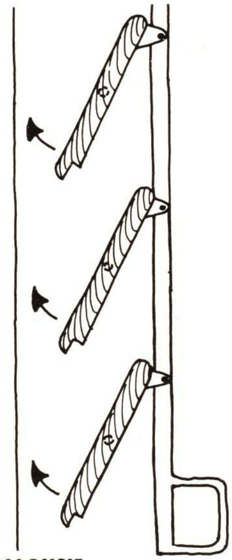
For most flexible light control Venetian blinds remain among the leaders, though their prime disadvantage of poor visibility is no more than modified by being able to pull the blind up out of the way when unneeded as a sun shade. Interlocking aluminum slats can now extend the range of this blind's light control to complete darkness.

Due to the depth of the bundle of slats when the blind is raised, it should be hung far enough above the window head, preferably in a pocket, that it does not protrude into the sash area. The new enclosed head box, including the tilt bar, has a depth of only 2½ ins., about 1 in. less than the open head box. The depth of the slats when stacked range from ¾ in. per ft. of extended blind depth (for metal) to 1¾ ins. (for wood).

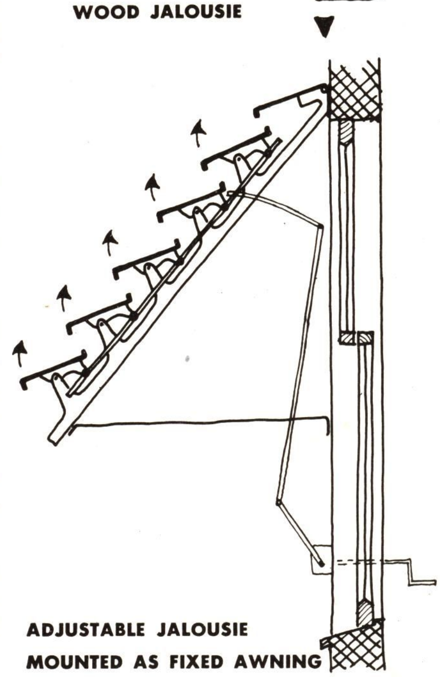
To avoid the blind rattling in the breeze it is worth fitting a sill bracket to hold the bottom bar when fully extended, also rubber-tipped guide pins—one every five or ten slats—sliding in a guide track on each jamb.

Halfway between the Venetian blind and the roller shade is a sunshade with vertical slats of fabric (W. Houmère), adjustable like a Venetian blind. When not wanted it can be rolled up out of the way like a roller shade. The operating cord which rolls the shade up and down also controls the turning of the slats. These overlap each other slightly, so that the blind is light tight when closed.

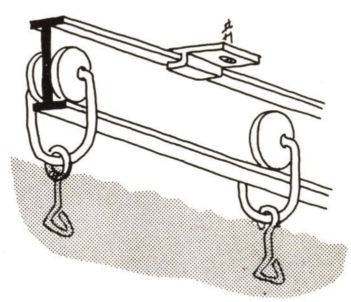
Materials for curtains are of infinite variety, but there are only two methods of hanging those which are to be movable across the window: by rings on a rod, or by a set of wheeled trolleys on a metal track. The latter naturally gives the smoother action and should be used for all but the lightest curtains. Rings work more easily when rigged with cords and pulleys to give a direct lengthwise pull along the rod.



WOOD JALOUSIE



ADJUSTABLE JALOUSIE
MOUNTED AS FIXED AWNING



I-BEAM CURTAIN TRACK

STOCK WINDOWS

Stock windows range from the small one-sash Basement window to large and various combinations of fixed and opening sash combined into a single prefabricated unit. Each unit is designed for connection to any sort of building structure (see Installation, pages 44-49) or to another window unit. Yet, thanks to factory production and standardized sizes, stock windows are not expensive. If you doubt this compare the price of a custom-made unit. The stock window, in fact, is the only highly developed type of prefabricated wall unit now commonly used in all types of structure. We are still awaiting perfection of solid wall units, of some equally adaptable design, to fill economically the interstices between the windows.

The number of stock window *types* is continually increasing, but recently, spurred by the need for modular coordination, the number of different unit *sizes* has been decreased. For large orders, however, the manufacturers are usually willing to make up some special size, using stock sections, without extra charge. If there is still doubt as to the varied and successful results possible with stock windows, it is only necessary to thumb through the pages of Windows in Use which follow (pages 50-122).

However, as always in the production of building materials, there is a lag between what design demands and what manufacturers consider it economical to produce in quantity. For example, air conditioning with its need for higher standards of heat resistance in windows; some provision for scientific control of light, the potentialities of which are only just now being realized; the tendency toward separation of the two functions of a window, lighting (by fixed sash) and ventilation (by screened louvers); the need for closer co-ordination between windows and accessory fittings for curtains and blinds — all these needs stock windows still leave largely unsatisfied; but it is only a matter of time before manufacturers will find it worth their while to produce fenestration of the types needed.

When considering the merits of one window against those of another, it is well to have clearly in mind the fundamental of window design, which is the weatherproofing of joints. First there is the joint between glass and sash frame. The frame should be rigid, the jointing material flexible to take up the movement of two materials with different co-efficients of expansion. Normally in stock windows putty is used for this elastic joint. In many of the extruded metal windows, where it is easy to manufacture complex shapes, the putty is contained and protected in a small pocket closed by a spring glazing bead (see pages 39, 42). The use of rubber and plastic gaskets in place of putty is still confined to more experimental windows, and to the exacting conditions imposed by industry and by transportation vehicles (see page 122).

Usually an attempt is made, by projecting drips above any vulnerable joint, to shed the intrusive water before it has a chance to reach the joint. The next line of defense is a series of tightly overlapping members with staggered joints between. In most windows there is a break somewhere in the thickness of any through joint to prevent water being drawn through by capillary action. In others any water that may penetrate the outer defenses is trapped in an intervening gutter whence it is drained back to the outside through weepholes. In Z-section metal windows some type of wedge-action handle maintains tight contact between the two flat-rolled, parallel surfaces (the edge of one against the flat of the other, as still occurs in some Industrial windows, is not so efficient). In high-class wood windows contact is maintained in spite of shrinkage and swelling of the wood, by spring metal weatherstrips.

In the following thirteen pages we have attempted to give a panoramic review of the stock windows available today, by picking out a few typical models for closer examination. The first seven pages deal with wood windows, the last six with metal. Obviously this does not give anything like a complete listing, it is simply intended as an introduction to the manufacturers' catalogs. No criticism is intended of the many, many, windows which we have been forced to leave unmentioned.

AS TO THE DRAWINGS . . . .

Here are the conventions to which we have held in this section. In the little key drawings all windows are seen from the outside. The hinge side of a vent is indicated by the pointed end of a dotted V. Applied to a pivoted vent, this results in an X.

In Vertical Sections the outside is always to your left. In Horizontal Sections the outside is always toward the bottom of the page.

Hardware is shown only where it seemed to help an understanding of the details. Almost all the windows are shown with single glass; most of them could equally well be fitted with sealed double glazing.

Manufacturer's credit is given when we show a window of special type peculiar to one manufacturer, but not when generalized details are shown, as, for example, in the hot-rolled steel windows.

WOOD WINDOWS

Due to the ease with which wood can be worked using only simple tools, equally with the elaborate and accurate machinery of a mass-production factory, the stock wood window can demonstrate all the stages between handcraft and factory production. There are few carpenters now who find it worth while to cut their own moldings; but many of them will form stock sections into a frame in their own shop, especially in such simple items as storm sash and screens. Many more, however, will buy sash and frame ready-made, and usually prefitted, though the two may be bought separately. To make a high-grade window it will then be necessary to buy and fit hardware, weatherstripping, screens, all of which means a considerable amount of hand work. This may be done on the site or in a local shop.

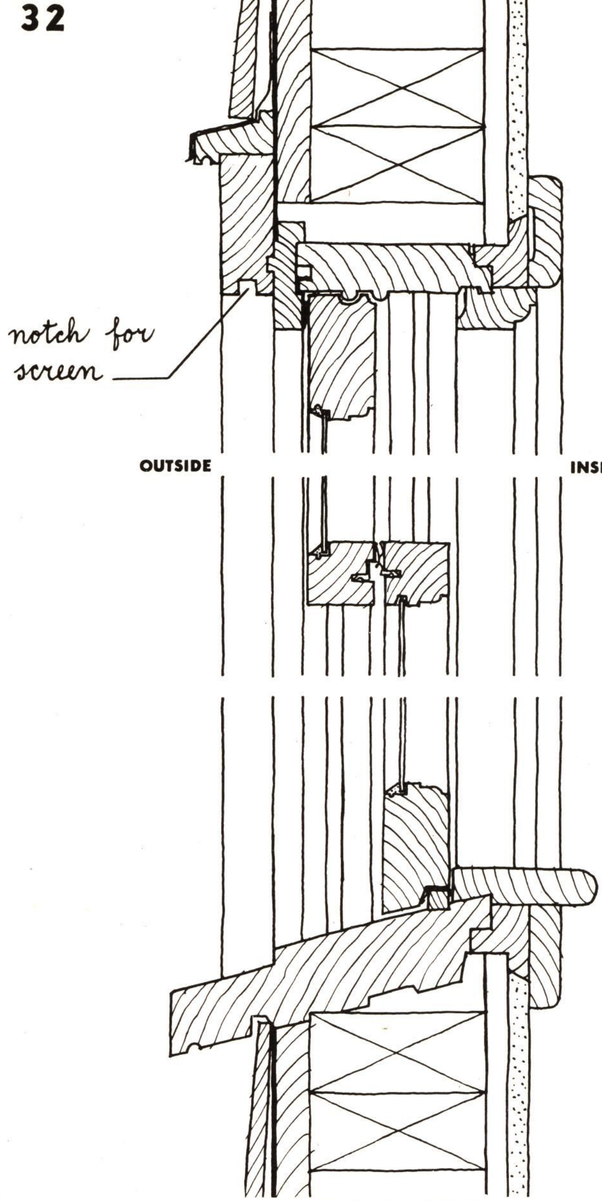
Such windows have the advantage of low cost and adaptability. Standard parts are available for any design changes. With a little ingenuity they may give almost custom-made results, though the sensitive designer is often put off by their generally thick and clumsy sections.

All the windows so far described require varying amounts of handwork before they are ready for use in the building. Opposed to these are the stock windows completely prefabricated in the factory (in some cases even glazed) which are delivered either knocked down or completely assembled ready to be fitted into the window opening without further work than uncrating. In their design such windows usually take advantage of that more efficient integration of elements which complete prefabrication and specialized machinery make possible (cf. pages 32 and 33). Made and fitted together in the same factory, often incorporating some improved design of weatherstripping and balances, such a window is almost inevitably more efficient than one put together by anybody but a first-class carpenter. It is also usually narrower and more refined in section. But it is less adaptable to changes in design.

Manufacturing standards for wood windows are set by the National Door Manufacturers' Association; they may be slightly modified by local usage. Standard sizes, based on modular co-ordination, vary by 4-inch steps. Woods used are usually white pine, cedar, or cypress in the East, fir, sugar pine, or redwood in the West. The stiles of double-hung windows should be of yellow pine, oiled and not painted. By dipping in a special toxic oil, sash and frame may be protected against decay caused by various fungus growths.

The pictorial index at right shows the commonly available types of wood window. Installation details for all of these are described and illustrated on pages 44, 45.

INDEX WITH PAGE NUMBERS



VERTICAL SECTION

DOUBLE-HUNG

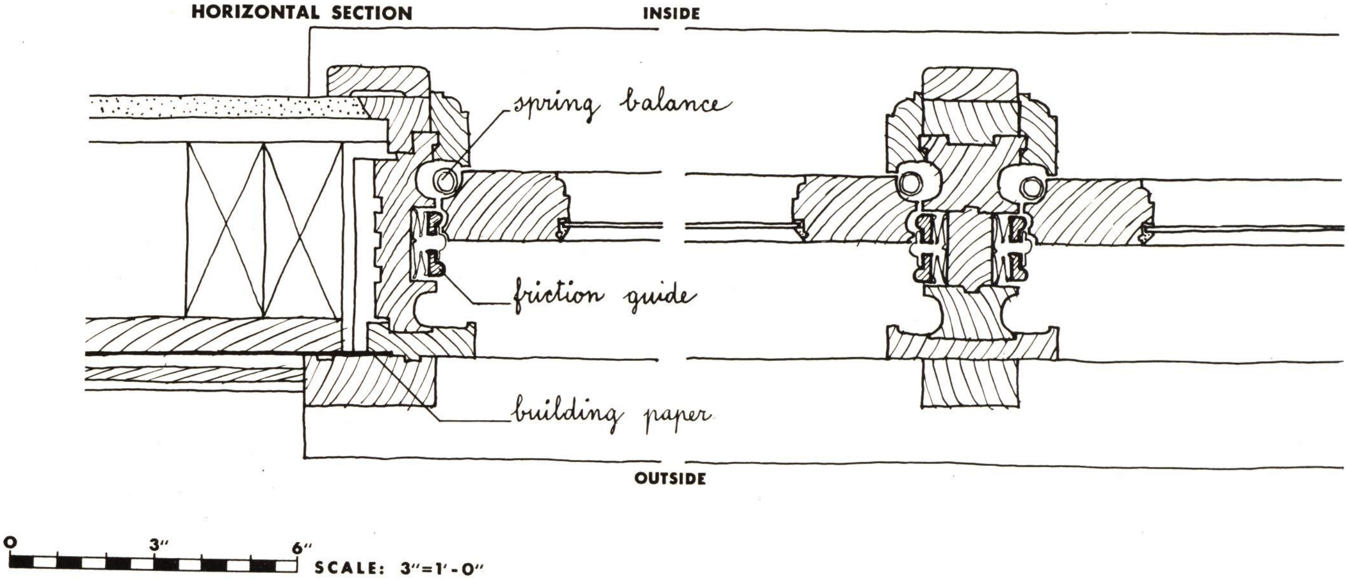
On these two pages are compared the standard conventional double hung (opposite) and a typical integrated modern double hung, the Curtis Silentite (left and below).

The former usually has no brand name; sash and frame may even be by two different manufacturers. The parts being of standard section may be easily adapted to special conditions. Notice that the blind stop (10), instead of being a single piece, has a reversible extension (5) which will fit either ½-in. or ¾-in. sheathing. Similarly the sill windbreak (23) is made with a saw kerf which allows it to be easily split at the job if it has to fit ½-in. sheathing. The sash may be balanced by counterweights, as shown, or by any type of spring balance (see page 20). Screens, storm sash, hardware, weatherstripping are all bought separately and fitted together on the site or in some local shop. For this reason weatherstripping (see page 27) is not shown on the drawing.

In contrast, the window shown on this page is completely prefabricated. It is of patent design which takes full advantage of factory production methods and machinery. The sash are balanced by coiled springs (see page 20) in combination with friction guides on the jambs. Seated on spring weatherstrips, these guides have a floating action which allows for normal shrinking and swelling of the wood yet keeps them operating weather-tight and smoothly. This is in strong contrast to the conventional fixed jamb which, unless carefully weatherstripped, will always be either too loose or too tight.

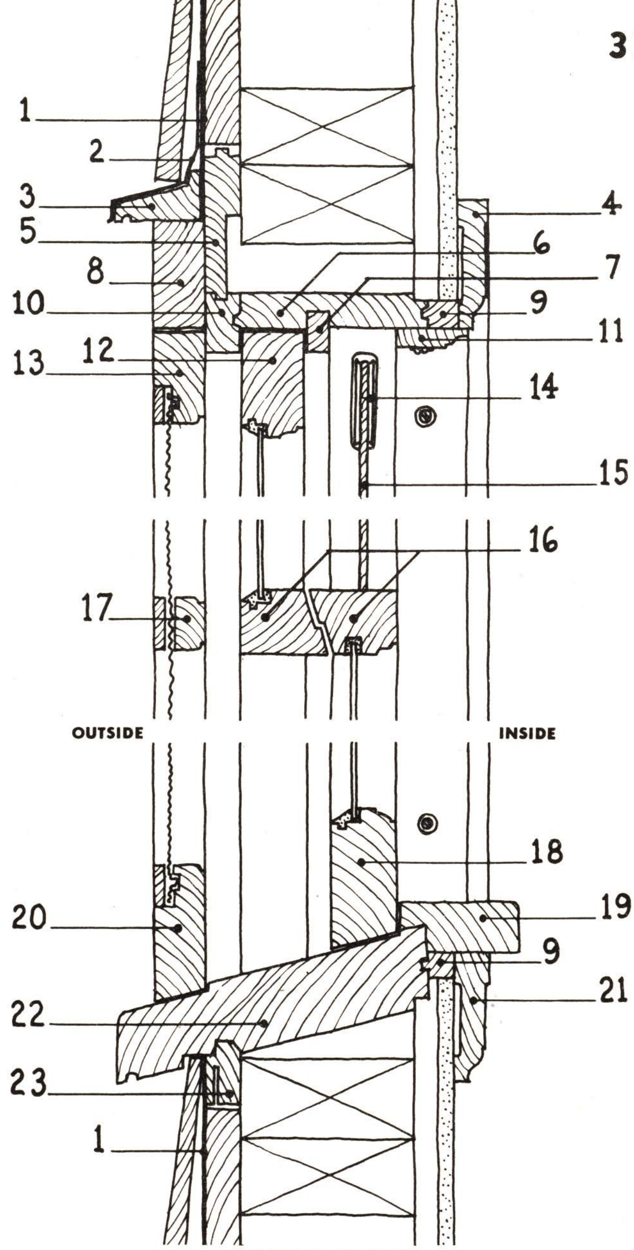
A worthwhile refinement in weatherproof construction is a recess on the blind casing to accommodate an overlap of building paper. The channel at the bottom of the outside casing is for the fitting of screens and storm sash of special design. Notice how much narrower a mullion is possible when spring balances replace counterweights. This is usually a most important factor in appearance.

HORIZONTAL SECTION

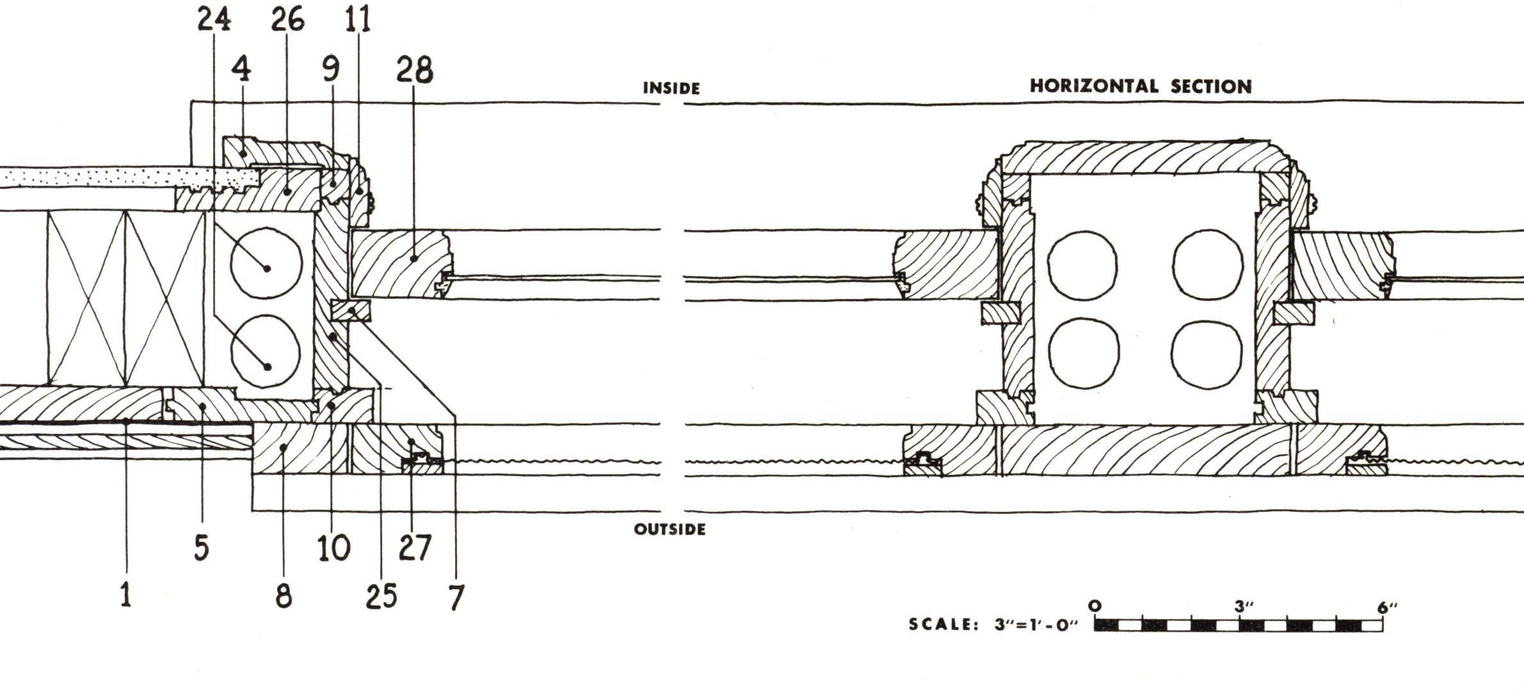


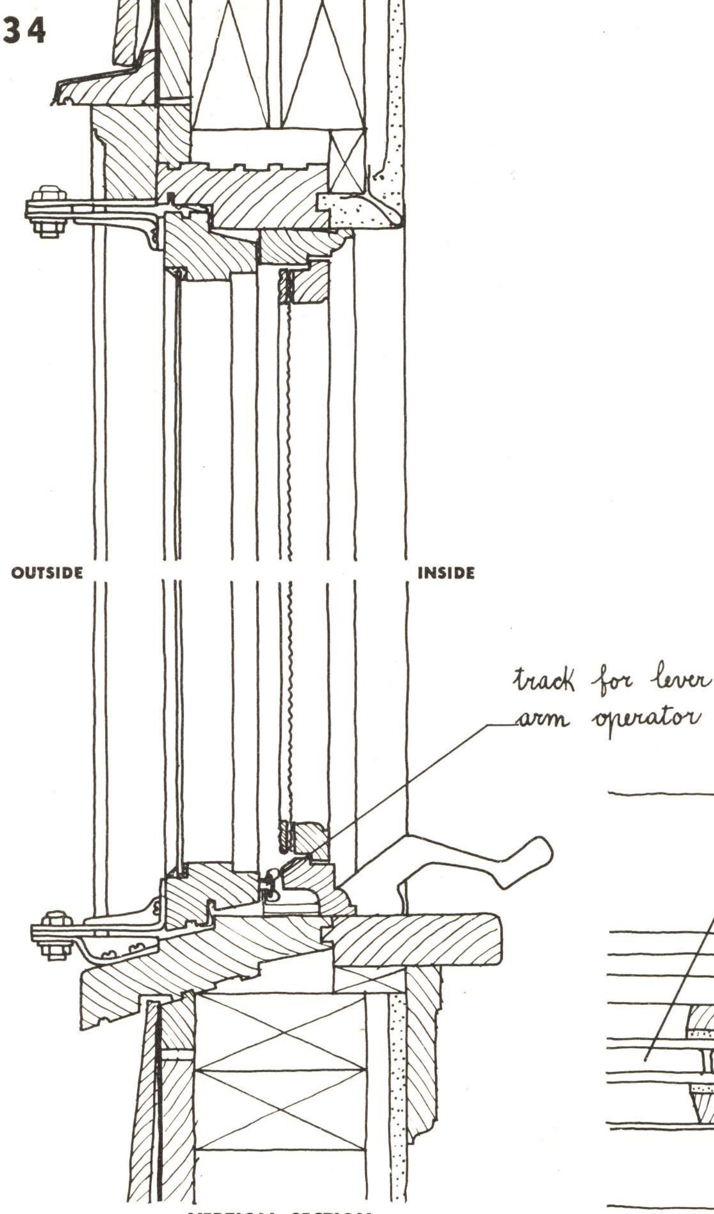
Key to numbered drawing for nomenclature of the parts which make up a conventional double-hung window. Many of these same parts—particularly those comprising the window frame—will occur in other types of wood window. This drawing is based on standards set by the National Door Manufacturers Association. These standards may be modified slightly by local usage in different areas.

1. Building paper
2. Flashing
3. Drip mold
4. Interior trim
5. Blind stop extension
6. Head
7. Parting strip
8. Outside casing
9. Jamb liner
10. Blind stop, or blind casing
11. Stop bead
12. Top rail
13. Top rail of screen
14. Pulley
15. Cord
16. Meeting rails
17. Center rail of screen
18. Bottom rail
19. Stool
20. Bottom rail of screen
21. Apron
22. Sill
23. Sill windbreak
24. Counterweights
25. Jamb, or pulley stile
26. Inside blind casing
27. Stile of screen
28. Stile



VERTICAL SECTION



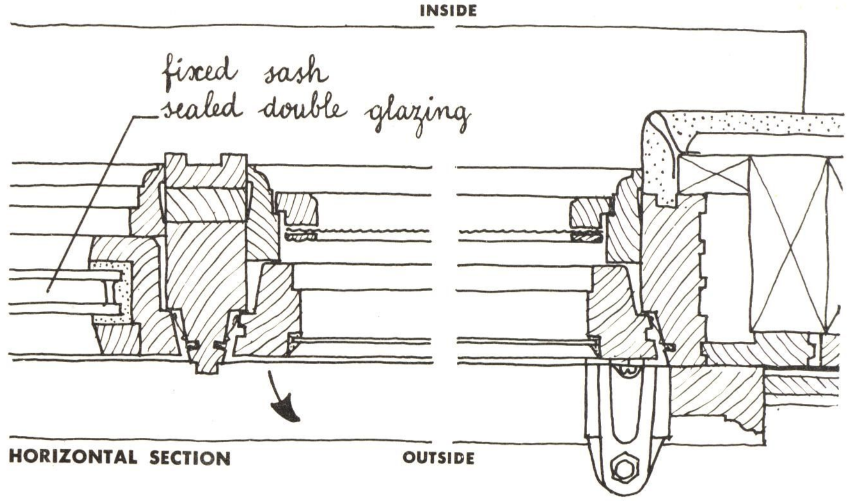


VERTICAL SECTION

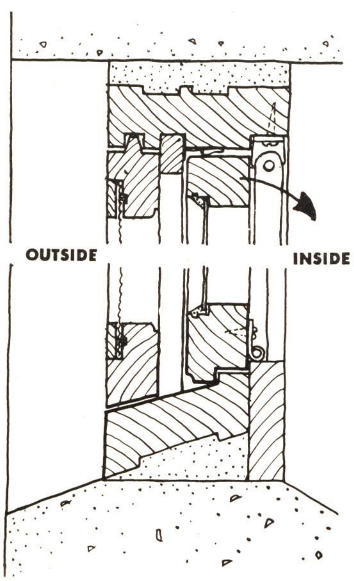
CASEMENT

This Andersen casement has ⅛ in. clearance all around between sash and frame; the contact between the two is by spring weatherstrips. These give constantly dependable, weatherproof contact without danger of jamming or air leakage, despite the normal shrinkage and swelling characteristic of any wood window. On the bottom rail this weatherstripping is combined with the track required by the lever arm of the roto operator.

An extended blind casing and the sill windbreak together form a flange extending all round the window unit. Nailed to studs and headers this gives good weather protection. The deep thin rails of the sash combine strength with good sight. This is particularly noticeable at the mullions. The mullion detail also shows how fixed sash with sealed double glazing can be easily fitted to these standard members. The vertical section has been drawn to show a plaster reveal instead of the usual wood trim (cf. page 36).

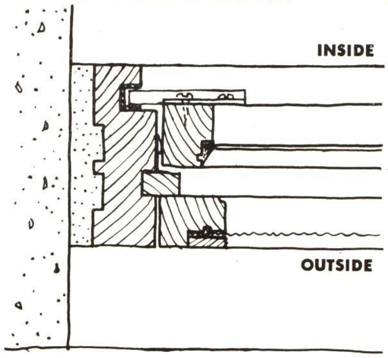


HORIZONTAL SECTION



VERTICAL SECTION

HORIZONTAL SECTION



BASEMENT & UTILITY

Basement window is the standard name for small, horizontal, in-swinging vents hinged at top or bottom. The one shown here (by Curtis) is hinged by two pins which slide in grooves at the jambs, the opening position being controlled by a friction arm. If a completely clear opening is needed, the bottom rail may be slid up to the head, the sash then standing out at right angles to the wall. Such a convenient, neatly-finished window has many possible applications outside the basement.

Utility windows are similar to Basement windows but have a panel of fixed sash below the opening sash.

SCALE: 3″=1′-0″

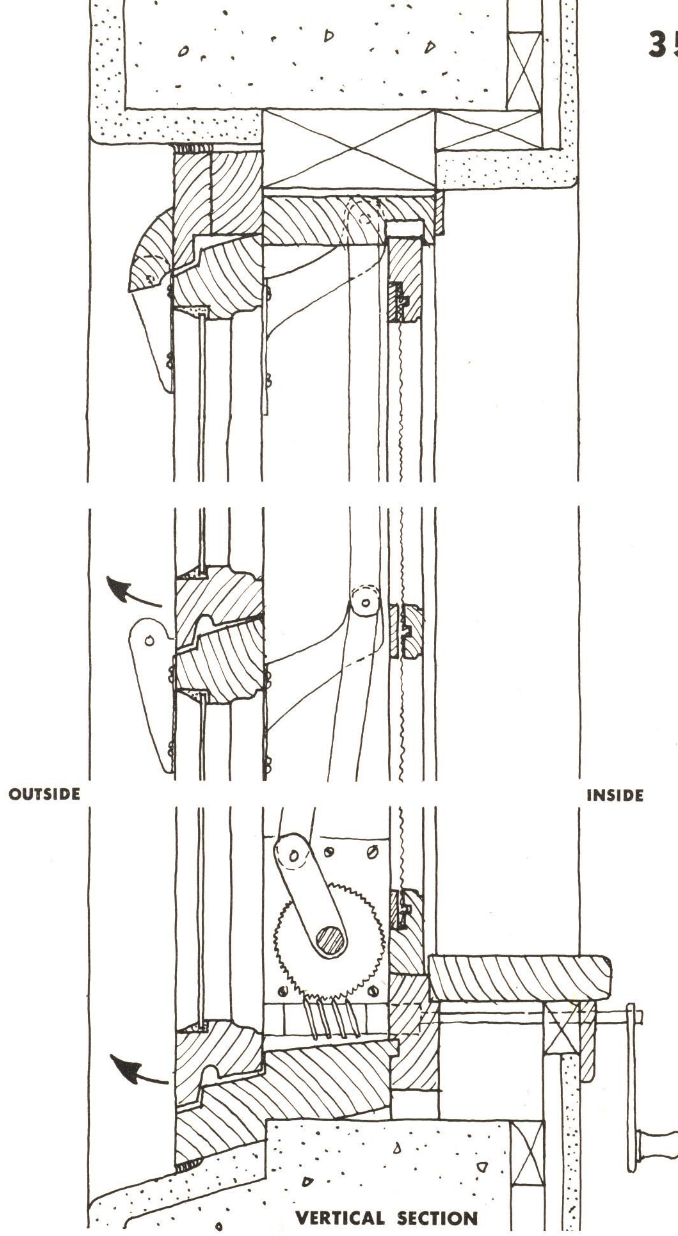
AWNING

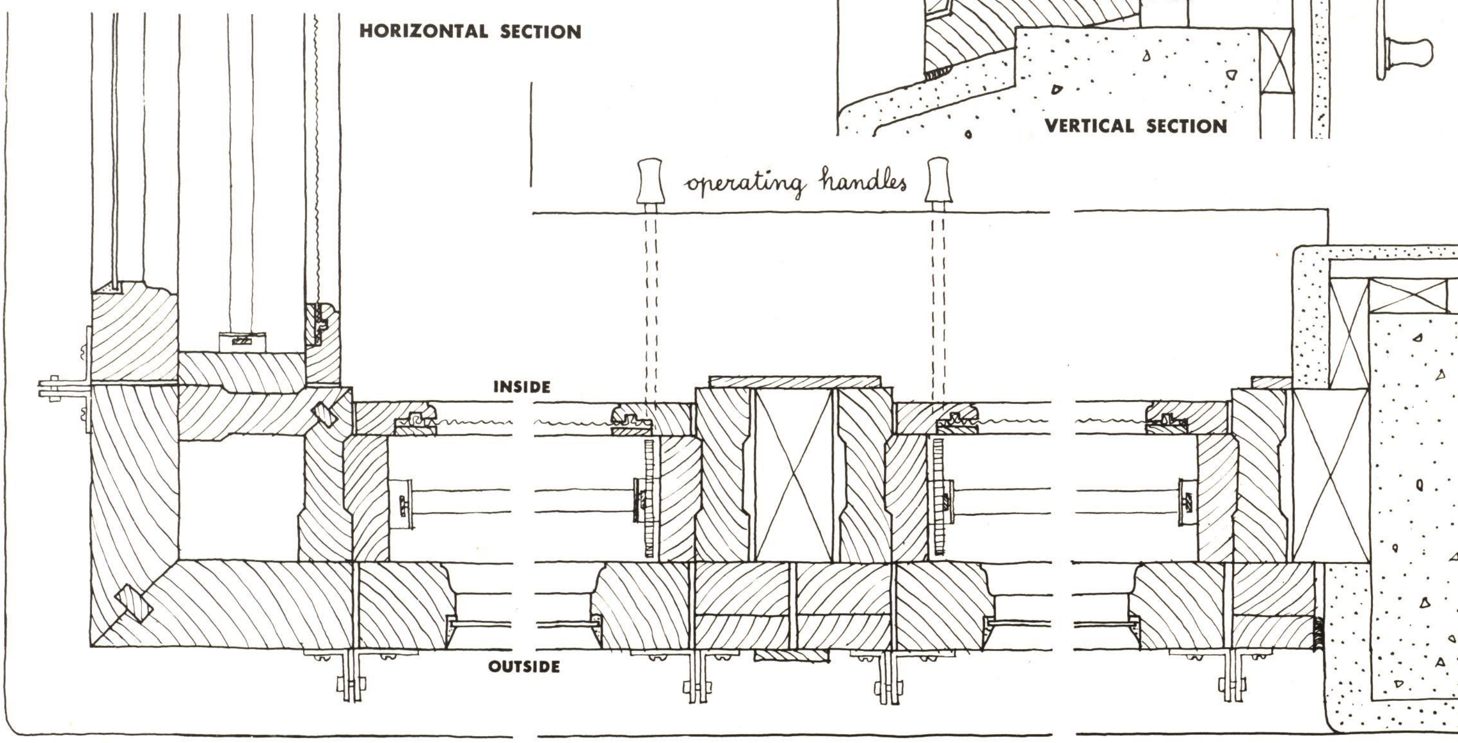
In this type of window the vents, though top-hung, are hinged by brackets to the jambs. The top rail of one vent interlocks with the bottom rail of the vent above. To prevent rain being dragged through this joint by capillary action, there is a deep groove cut the length of each bottom rail on the under side.

Until recently awning windows were almost entirely confined to the warmer sections of the country. Such a window as this (by Gate City Sash) has there the advantage of giving good ventilation, being easily screened, and preventing the rain from driving in when the heat is broken by a drenching tropical storm. The semi-tropical background explains the lack of weatherstripping. Now that the advantages of the awning window are becoming appreciated outside the South, we may expect to see a quantity of new developments in this type of sheltered ventilation.

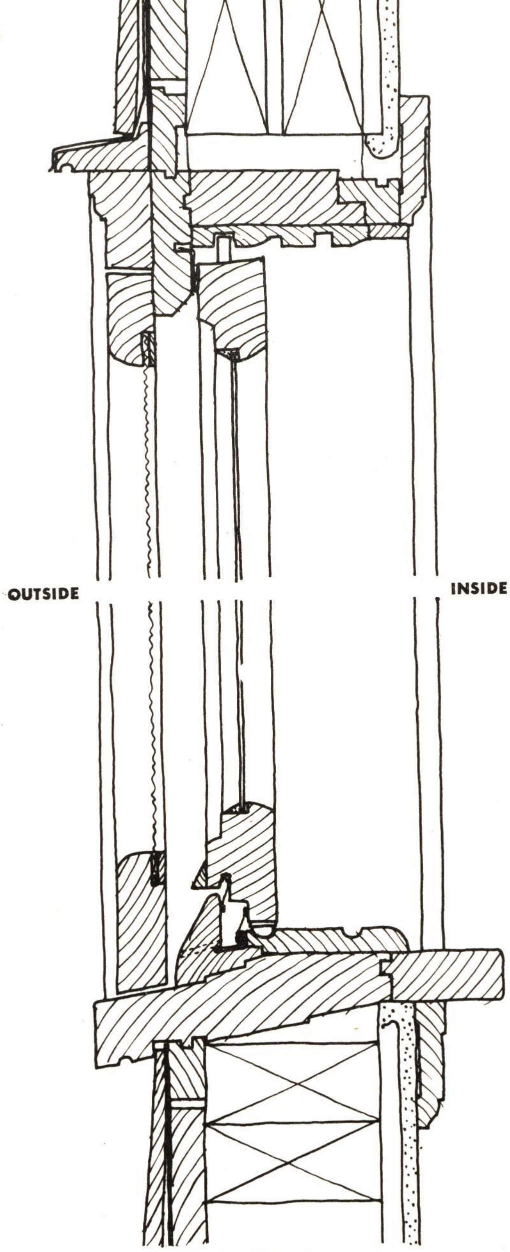
All the vents open simultaneously. At each jamb projecting lever arms on the vents are connected to a vertical bar operated by worm and gear mechanism, with an operator projecting at sill height. This mechanism is here left exposed, in character with the simplicity of this window. The drawing shows installation in a concrete block wall, a typical condition, especially in tropical climates where there is danger of termites, fungus, decay.

There are other so-called awning windows which have a Projected action (see page 19) so allowing the top vent, as well as all the others, to be cleaned from inside, for the top rail moves down as the vent opens awning-wise.





SCALE: 3″=1′-0″ 0 3″ 6″

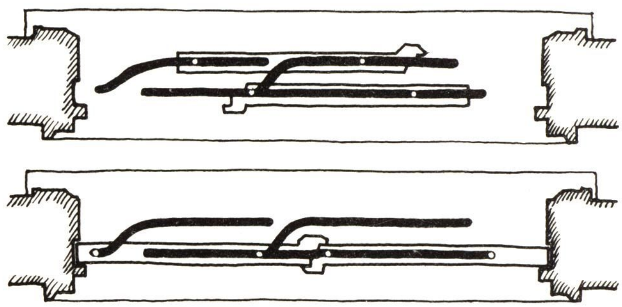


VERTICAL SECTION

HORIZONTAL SLIDING

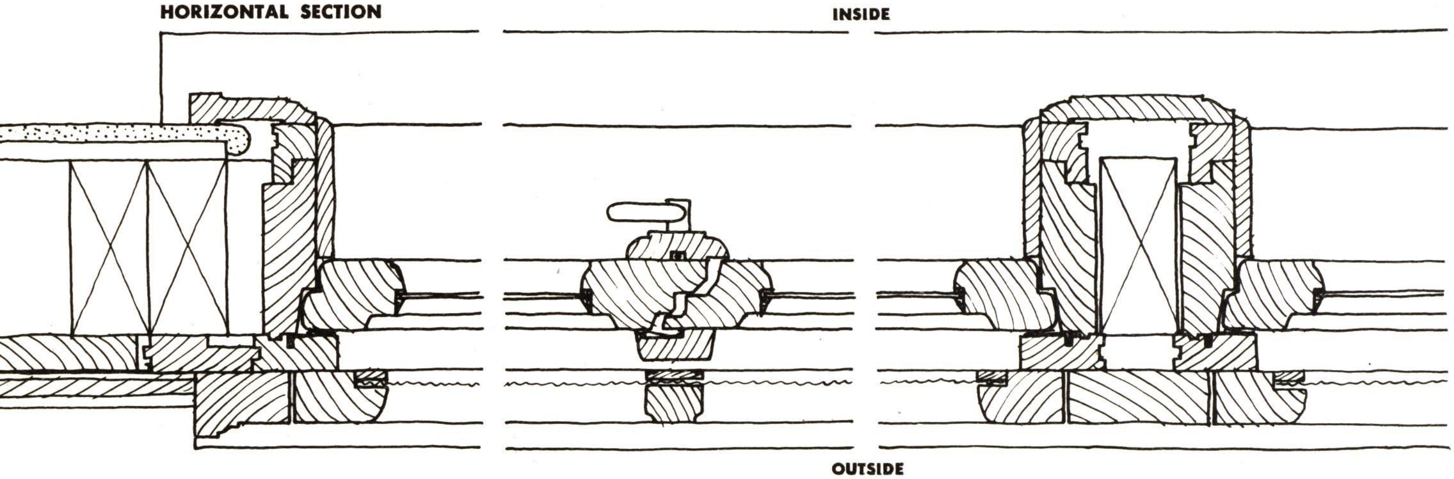
There is always some difficulty in making horizontal sliding sash weatherproof, particularly at the bottom and meeting rails. The former is protected in this case by a projecting dripmold and two separate spring weatherstrips. Any water which may manage to work its way past the outer weatherstrip will collect in an intervening gutter whence it is drained off through weepholes. At the meeting rail a series of three weatherbreaks is climaxed by a spring weatherstrip in an overlapping batten. To keep the two sash tightly aligned, the central handle acts on a long bolt which locks into the frame at head and sill.

The sash slide on metal domes in grooves in the hardwood sill. Spring-loaded projecting guide pins slide in similar tracks at the head. The whole sash may be lifted out for cleaning or to give an unobstructed window opening. In this window (by Andersen), as in the Casement shown on page 34, the blind casing and sill windbreak are extended to form a flange all round the window unit. We have shown this window set in a reveal finished with wood trim. It might equally well be set in a plaster reveal as shown on the Casement drawing.



DIAGRAMMATIC PLAN WITH SASH OPEN *(TOP)*, CLOSED *(BELOW)*

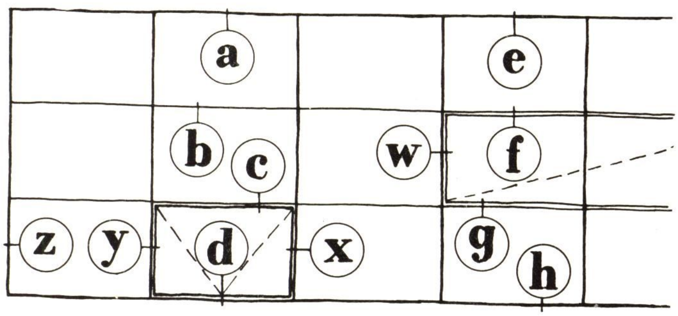
HORIZONTAL SECTION

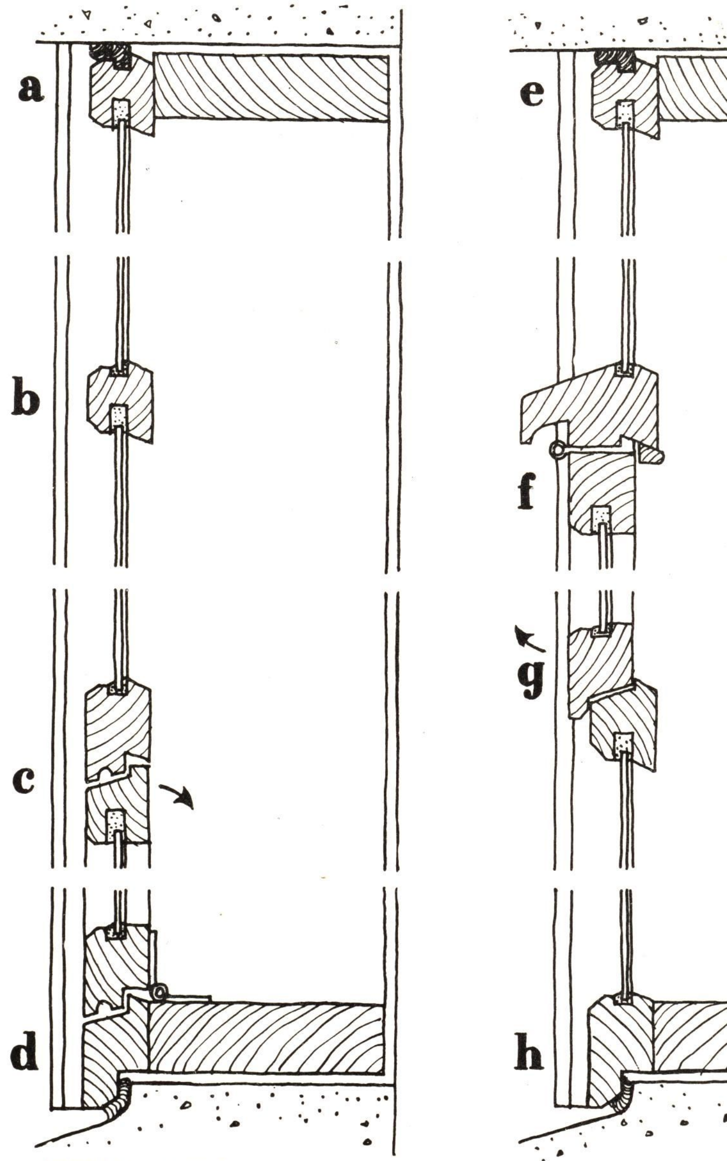


WINDOW WALL

Instead of a series of prefabricated window panels joined by mullions, this window wall (by Geyser) is a regular grid, made of pre-cut members assembled on the site, into which may be set fixed sash or vents in any arrangement which the designer may specify. This is an attempt to bring the benefits of standardization and pre-cutting to the sort of window wall which many designers now want.

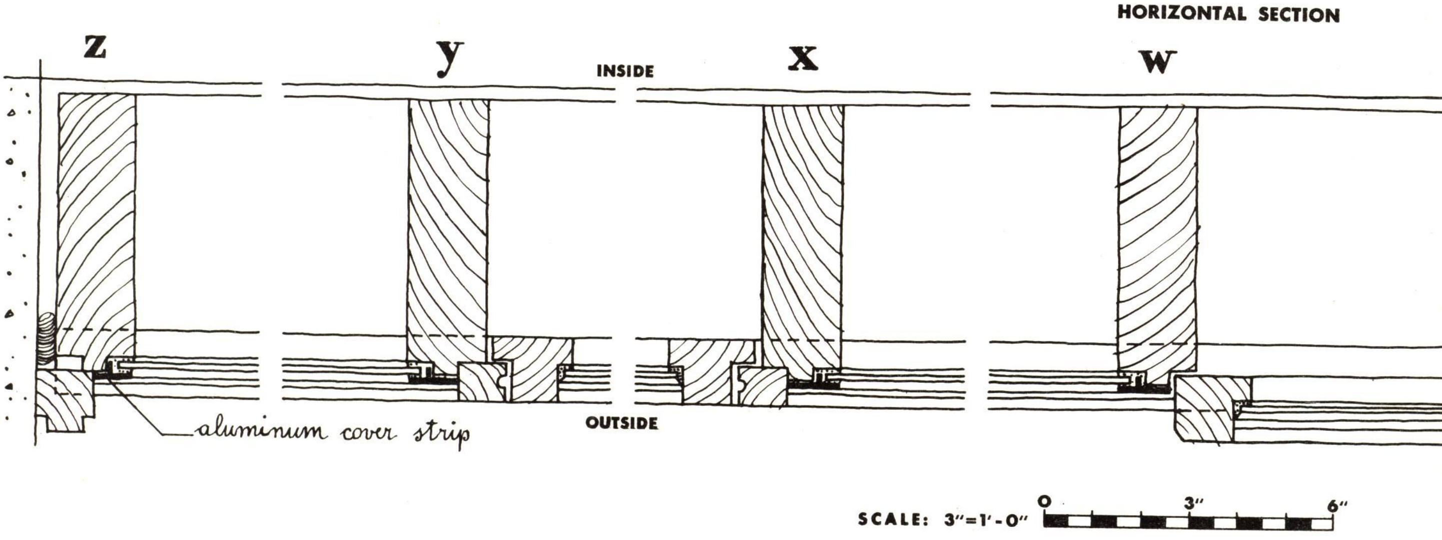
Heavy verticals — their depth varied according to the size of the window wall—are fitted to continuous head and sill members. Light horizontal rails are notched into these verticals, the outer face of the rails varying slightly in section depending upon whether they are to house fixed sash or provide a frame for vents. These vents may be of almost any type, top-hinged, bottom-hinged, or continuous. All glass, in vents or fixed, is held in two putty-stuffed grooves at top and bottom, the top groove being slightly deeper than that at the bottom. The glass is fitted by being lifted up into the top groove and then dropped down into the bottom one. On the face of each vertical member continuous metal cover strips are fitted to protect the joint between wood and glass.





VERTICAL SECTION

HORIZONTAL SECTION



SCALE: 3"=1'-0"

METAL WINDOWS

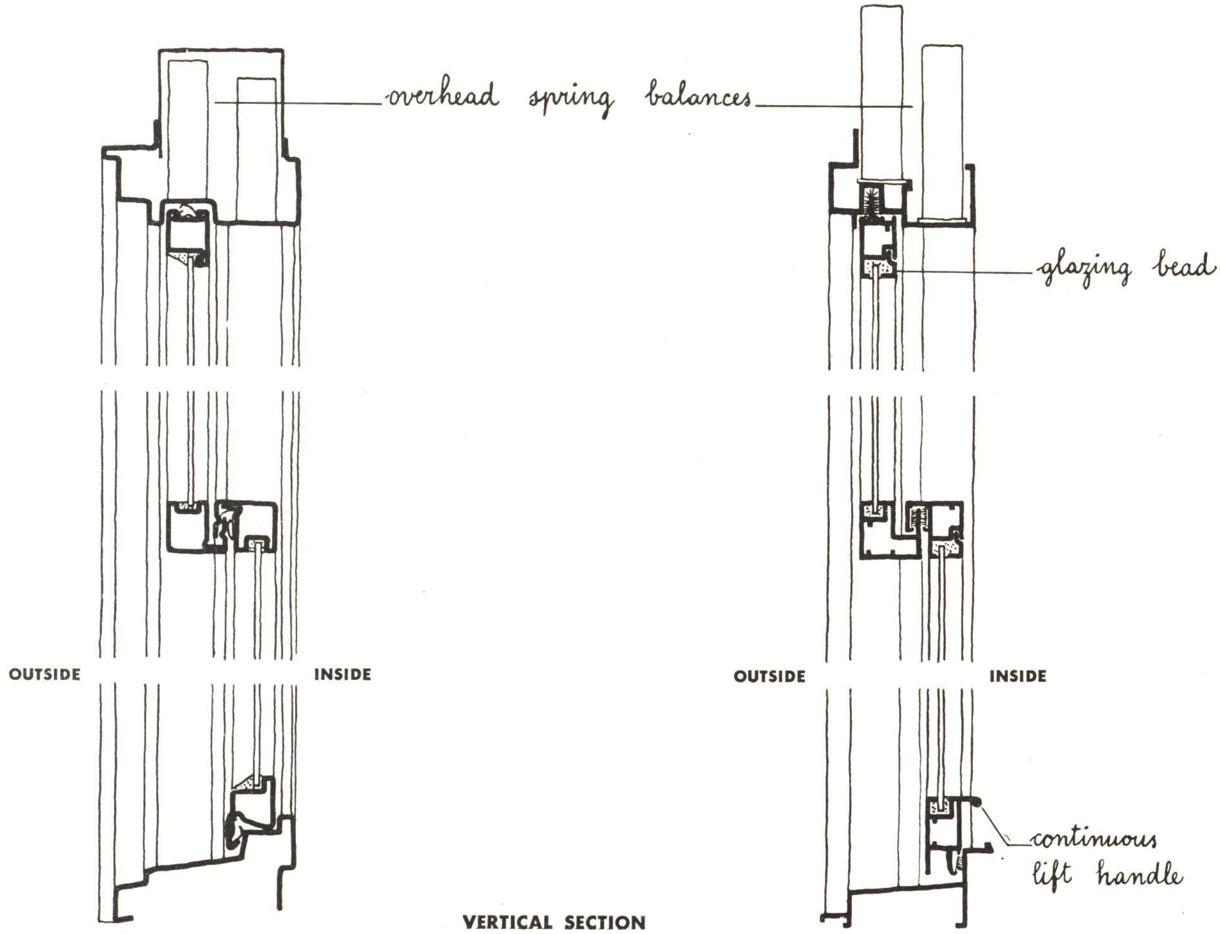
All stock metal windows available today are of steel, bronze, or aluminum. The two latter, by corroding, build up a protective coat which prevents further corrosion; so they do not require the additional protection of paint. Steel, however, unless it be of stainless type, will continue to corrode unless separated from the atmosphere by an unbroken covering. The most usual practice is to give the cleaned metal a coating of iron phosphate (as in Bonderising and Parkerising) which forms a good base for paint. Where steel frames are set in any porous material, or in masonry subject to moisture penetration, the hidden surfaces should be given a coat of asphaltum or similar protective material before installation.

Stock metal windows are manufactured by one of three processes—hot rolling, cold rolling, extrusion. Hot-rolled metal shapes may be in any number of different weights according to the strength required of them, but they can be economically produced only in a limited number of simple shapes, all solid bars based on the Z and L sections which have been found the most adaptable. In the cold rolling process (used almost exclusively for double-hung windows) steel sheet — from 12 to 24 gauge — is bent and crimped into rigid, box-like sections (see opposite page). Extrusion, the newest of the three manufacturing processes, can be economically applied so far only to the softer metals, aluminum particularly, and bronze. Complicated shapes are quite easily achieved by forcing the metal through a hollow die.

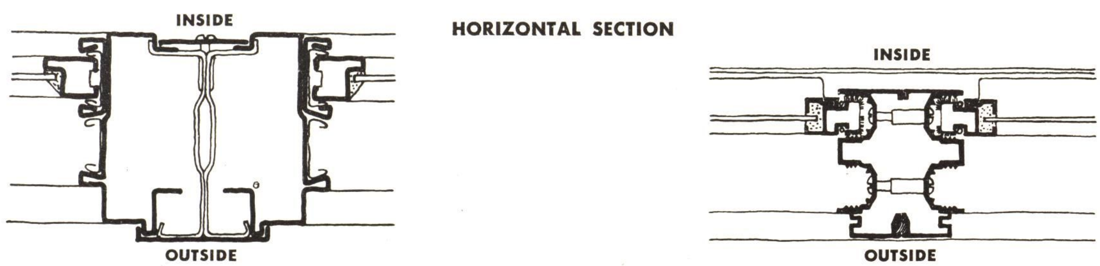
In the thickly-populated field of windows made from hot-rolled sections it is useful to have an understanding of the differences between the three main groups: *residence* (page 40), *intermediate* (page 41), *industrial* (page 43). The *residence* are of lightweight sections, are made in casements only,· are used mainly in small private houses. They are neatly constructed and weathertight. The *intermediate* are heavier windows, of more elaborate section, strong enough to span large openings, and made in projected vents as well as casements. The *industrial* windows are of rugged and simple construction, in some cases at the expense of weathertightness. In recent years these windows have taken over many construction features from the other two groups, to the improvement of *industrial.*

Co-ordinator of sizes and specifications for metal windows is the Metal Window Institute. All metal windows except *residence* casements are of modular size. The *industrial* windows, formerly built round glass sizes of 14 x 20 ins. and 12 x 18 ins., now conform to a 16 x 20 ins. grid on bar centers, which gives them a definite horizontality. Metal windows are usually delivered unglazed and without hardware fitted.

The pictorial index at left shows the commonly available types of metal window. Installation details for all of these are described and illustrated on pages 46-49.



VERTICAL SECTION



HORIZONTAL SECTION

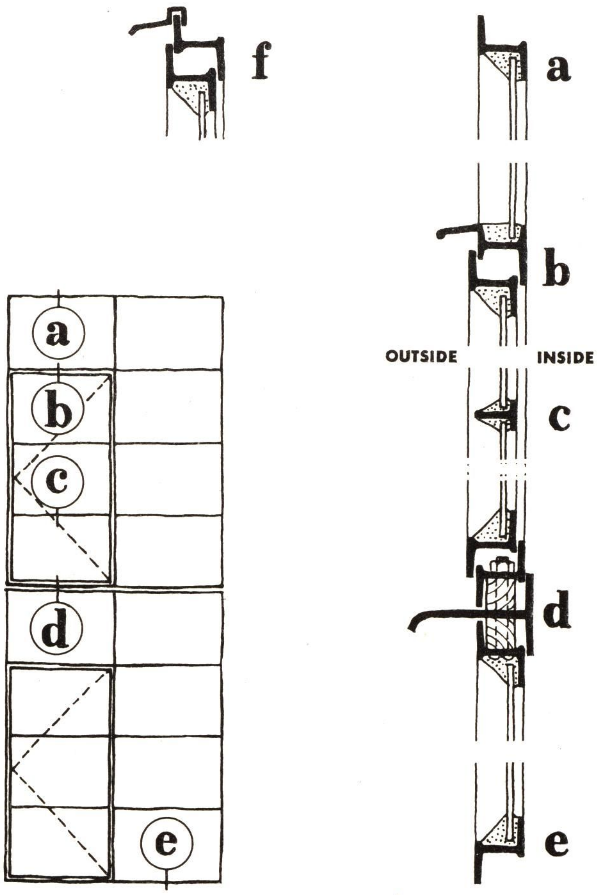
DOUBLE-HUNG

Two different manufacturing processes have produced here strikingly similar box sections. The window on the left (by Truscon) is of cold rolled steel, that on the right (by Adlake) of extruded aluminum. Either process can give elaboration of shape far beyond that possible with hot rolling (see sections on pages 40, 41, 43), but extrusion is particularly well adapted to produce complex shapes economically, usually in aluminum.

In both sash either the top or bottom edge of the glass is slipped into a channel of the frame, the other three sides being puttied against a conventional rebate. In the aluminum sash, however, these other three edges are covered, neatly and firmly, by a glazing bead sprung into a recess on the sash frame. Weatherstripping of the steel window is by spring metal, of the aluminum one by felt-covered projections interlocking with the window frame.

In both windows the mullions are excellently simple. The steel windows are held by clips connected to continuous plates on the inner and outer face. The aluminum window jambs are designed to fit against each other directly, so require only sleeve bolts, with a mastic-filled pocket formed on the outer face to ensure weathertightness.

SCALE: 3"=1'-0" 0 3" 6"



VERTICAL SECTION

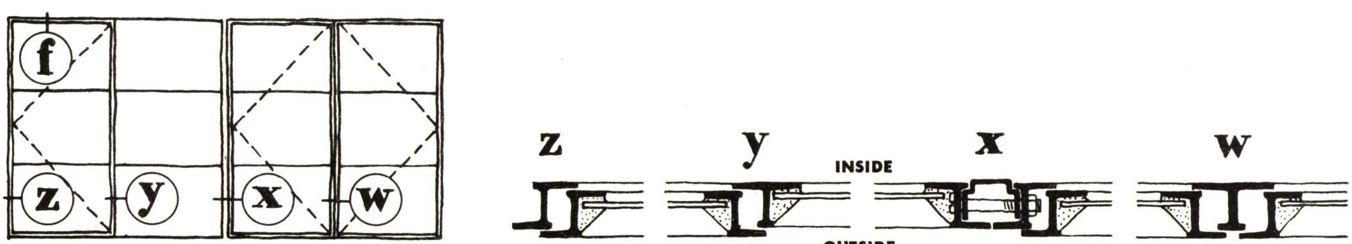
RESIDENCE CASEMENT

This window is almost entirely constructed from a single lightweight, hot-rolled, solid bar of Z shape. Two of the Z sections lapping over each other, as in frame and vent, give the standard two-point contact of rolled sections which is considered the essential of weathertightness. Horizontal and vertical joints between units are made by special mullions held by bolts and spacers.

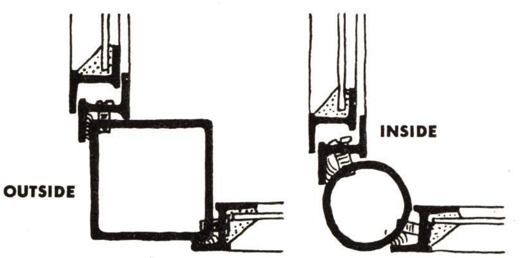
This is the only class of metal window in common use which still retains its old, pre-modular range of sizes. It is available as a "package" window, shipped complete and prefitted with a wood surround, for fast and simple installation in a wood frame dwelling.

Housing Casement. This uses the same lightweight Z section as the Residence casement, but it differs from the latter in being of standard modular size. For economy it is usually fitted with friction hinges and simple hardware operated through a wicket, if screens are fitted. The sash is usually framed in a sheet steel casing which acts as sill, reveal and plaster stop (see page 47).

Basement and Utility Windows. Basement windows are generally made from the same lightweight, Z-section bars as the Residence casement. They have a single horizontal, in-swinging vent, which may be either top- or bottom-hinged (as in this example by Hope's). In most cases the vent is held in such a way, without fixed hinges, that it can be easily removed from the frame when a clear opening is required. The Utility window is similar to the Basement window with a panel of fixed sash added below the vent.

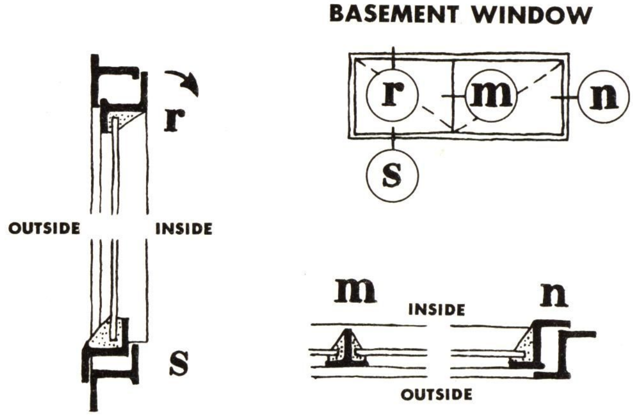


HORIZONTAL SECTION



CORNER MULLIONS : HORIZONTAL SECTIONS

BASEMENT WINDOW

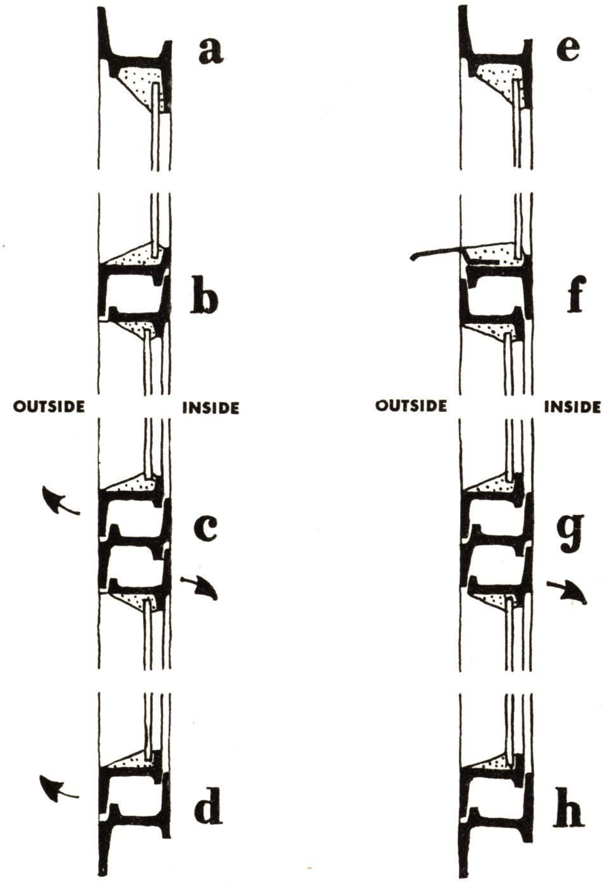


SCALE: 3"=1'-0"

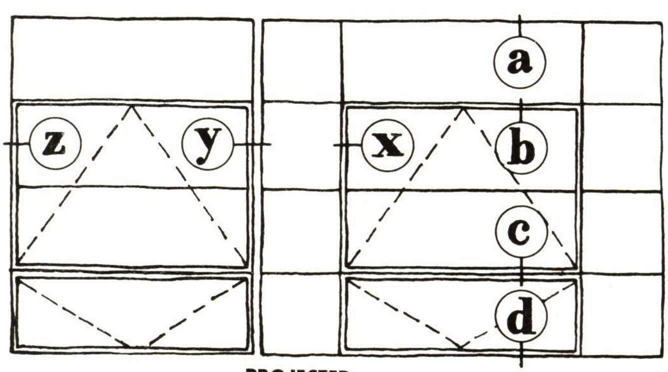
INTERMEDIATE WINDOWS

Included in this category are Casement, Projected and Combination (Casement with a Projected vent added) windows. Like the Residence Casements, these are built of hot-rolled sections, but of heavier weight and wider, more elaborate sections. The same sections are used, with minor variations, for special types such as Awning and Detention. They are also generally used for any high-class work such as custom-made windows, and where strength is needed for large openings. Similar profiles are obtainable from some manufacturers in even heavier weights. These are known as heavy windows.

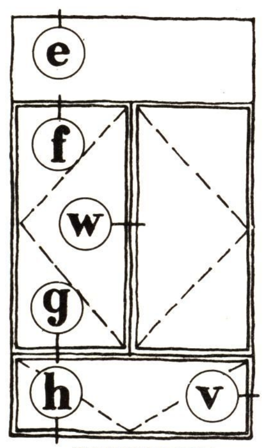
The basic Z section is still used here, but modified (in slightly different ways by different manufacturers) to serve a wide variety of different conditions with the smallest possible number of variations in section. This effort at rationalization of sections is forced upon the manufacturer by the high capital cost of the rolling equipment necessary to produce any new shape. But in no case will one find in these Intermediate and Heavy windows that two sections have been bolted together to form a new shape (as sometimes happens in Industrial windows; see page 43). These are high-class and comparatively expensive windows; they cannot afford the dangers of corrosion in such joints. Moreover considerable attention has been given to improving the appearance of these windows. Notice, for example, in these sections how frames and vents have offsets to give a flush exterior surface. The drawings do not show any one manufacturer's window. They are a composite of the most typical and widely-used sections.



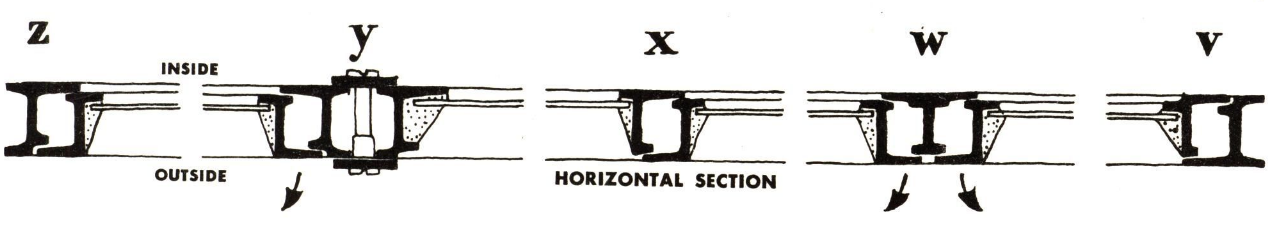
VERTICAL SECTION



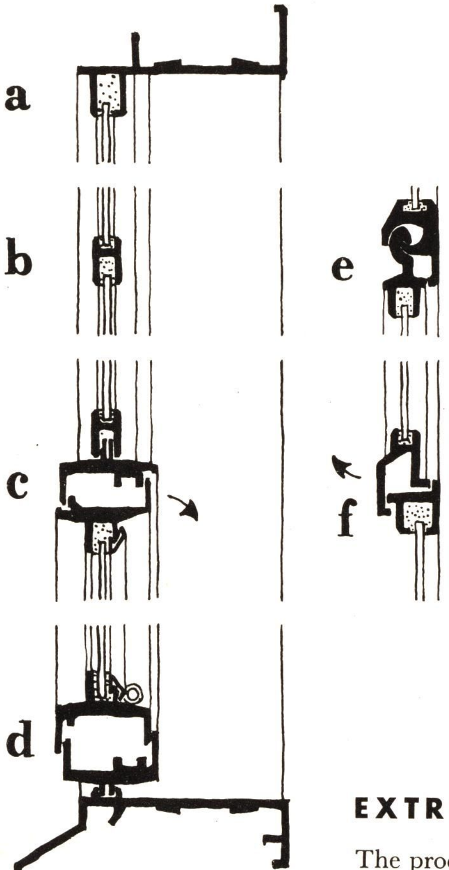
PROJECTED



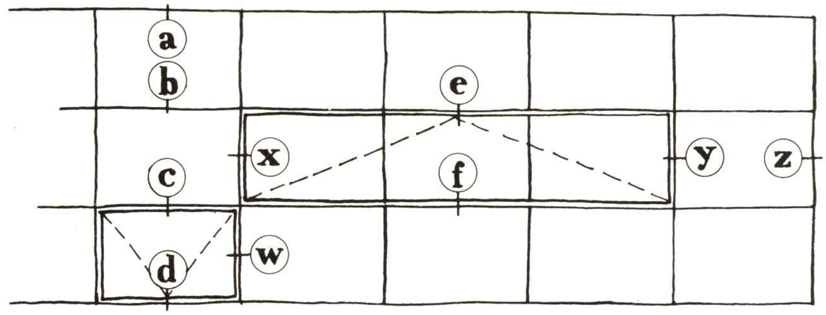
COMBINATION

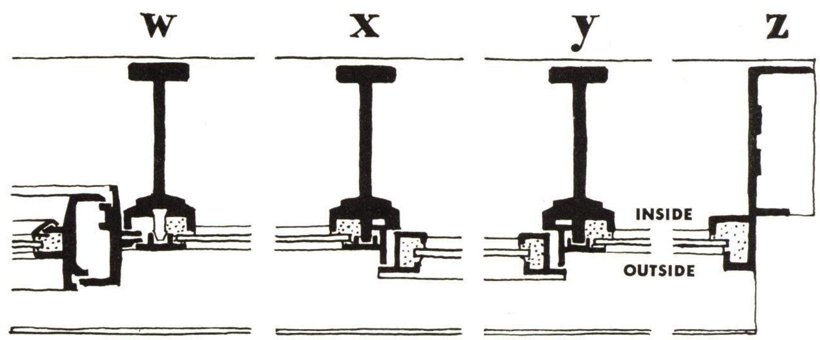


HORIZONTAL SECTION



VERTICAL SECTIONS





HORIZONTAL SECTION

EXTRUDED

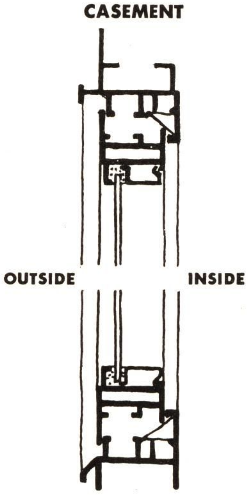
The process of extrusion allows complicated sections to be manufactured economically in the softer metals. It is commonly used for aluminum windows, often of new design.

Window wall (above) is an aluminum version of the wood type already shown (page 37). Light horizontals are notched into heavier uprights to form a grid. Into this may be inserted fixed glass or various types of prefabricated vent. Except where a continuous vent occurs the grid is of uniform section throughout, a vent being installed just as easily as a sheet of glass. All the framing members are precut, assembled on the site. (Geyser)

Casement (left). The complication of this section—not difficult to make by extrusion—springs from an attempt to satisfy all conditions. Weatherstrips of stainless steel (to avoid electrolysis) are sprung into pockets extruded integral with the frame. The glass is set in a putty pocket with neat turned-over edge on one face, a spring glazing bead on the other. (General Bronze)

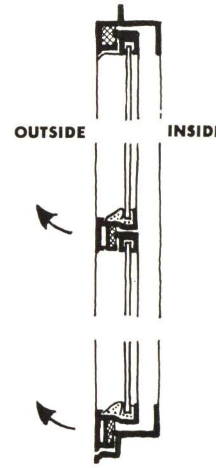
Awning (right). This is a simple lightweight vent hinged on the jambs. Notable is the elegantly thin section and the uniform appearance of fixed sash and vents. A felt-filled pocket is used for weatherstripping. Operation is by push bar through the jamb. (Construction Products)

CASEMENT

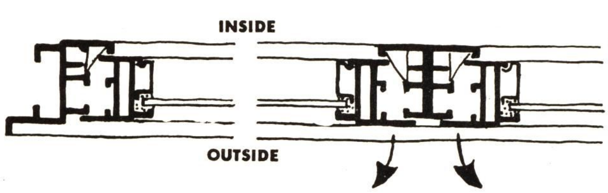


VERTICAL SECTION

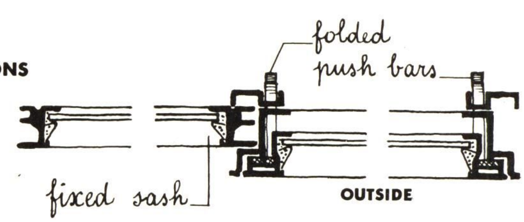
AWNING



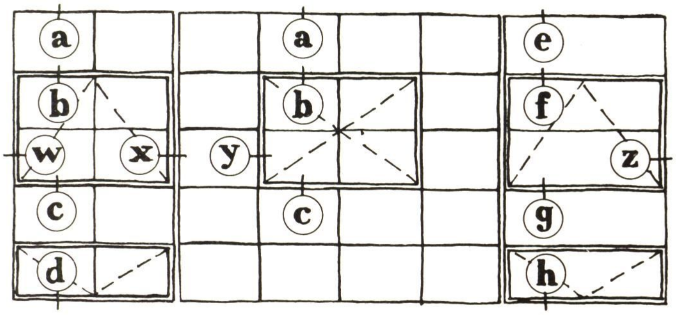
VERTICAL SECTIONS



HORIZONTAL SECTIONS



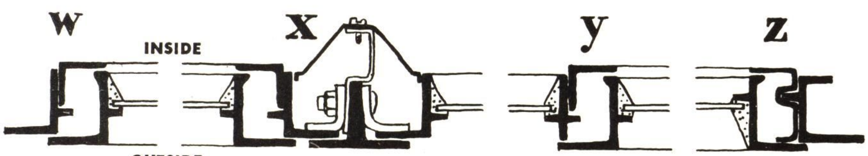
SCALE: 3″=1′-0″



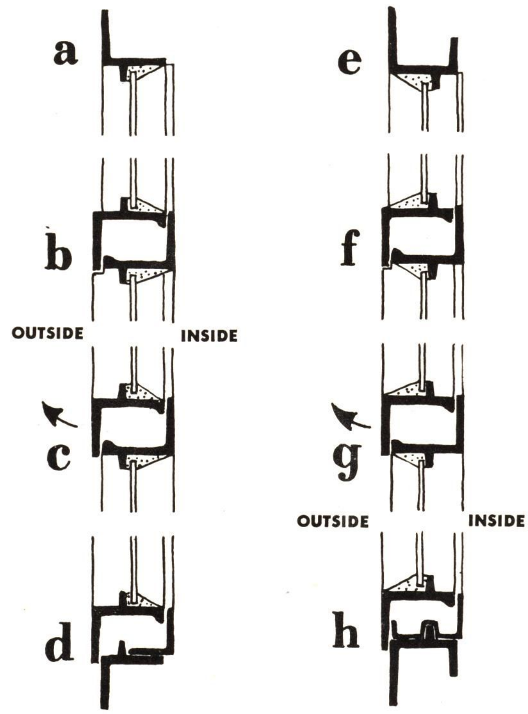
COMMERCIAL PROJECTED

PIVOTED

ARCHITECTURAL PROJECTED



HORIZONTAL SECTION

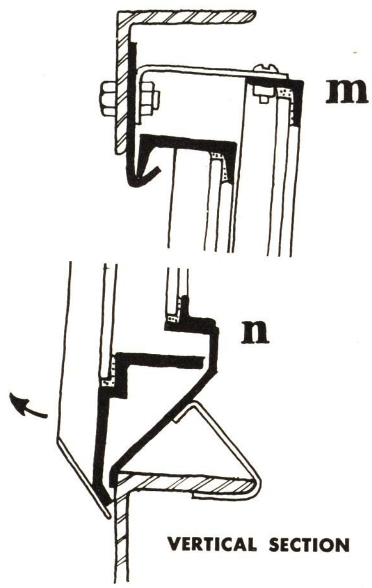


VERTICAL SECTION

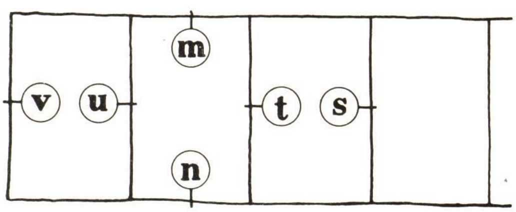
INDUSTRIAL

These are rugged windows intended, as the name implies, for industrial buildings. They are constructed from a very limited number of different sections, these being supplemented by angles which, bolted to the sections, serve as weathering baffles. Two basic types of Industrial windows should be distinguished: (i) Commercial Projected and Pivoted; these are made for inside glazing; (ii) Architectural Projected, of similar section but with outside glazing and better hardware. This is especially designed for use in the office section of factories, to harmonize with the Commercial Propected used in the manufacturing section. It is scarcely distinguishable in quality from the Intermediate Projected (page 41). From the drawings it will be seen that whereas the Industrial frame members have but one leg, the Architectural Projected have an extra, shorter leg to serve as a plaster stop.

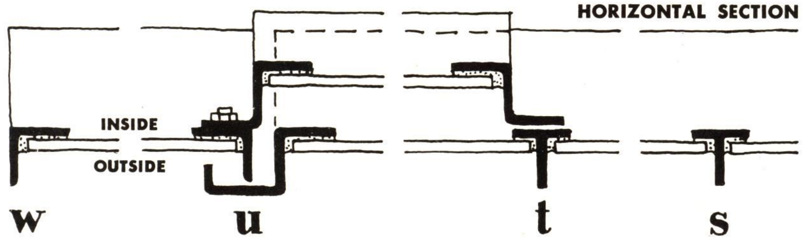
Continuous (right and below). This window has no frame in the normal sense of the term. It is applied directly to the steel or concrete structure of the building. Fixed baffles at each end channel away any rain that may come in at the sides. The window shown here (by Truscon) is notable for its continuous integral hinge. Such windows, in long runs, are usually mechanically operated.



VERTICAL SECTION



HORIZONTAL SECTION



SCALE: 3"=1'-0"

INSTALLATION DETAILS

No window, however carefully it may be designed and built, will perform well unless it is well installed. This installation is the fitting of a finished, prefabricated unit into a building structure which is still unfinished. The connection between building and window must be weatherproof. It must also be slightly elastic, so that any settlement of the building will not damage the window. This elastic connection also helps to absorb the vibration caused by opening and closing the vents in a window.

For the manufacturer of stock windows the problem of installation is complicated by the great variety of wall structures into which the stock window must be fitted. The problem is often solved by the addition of supplementary parts to a basic frame, in order to satisfy various requirements. Consequently some of the installation details suggested by manufacturers do not reflect the most direct answer to each individual set of circumstances.

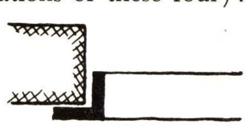
Windows may either be installed in *prepared openings* or *built-in*. In the first case the window is installed in a rough opening prepared in advance for its reception. A certain amount of clearance is left between the rough opening and the window frame, but this system nevertheless requires accurate pre-planning. In the case of built-in windows the wall is actually built around the window frame, which is held by braces during construction. In this way the window is encased in the wall structure. Which of the two systems is preferable depends upon the nature of the wall structure, and the scheduling and management of the construction program. The present trend is toward prepared openings in almost all cases. This system allows all the windows to be installed in a single, continuous operation. The window units are less liable to damage during construction, and they are more easily replaced, should the need for this arise.

To avoid cutting and patching on the site during installation, window dimensions must be co-ordinated with those of other building materials. Most are now designed for modular co-ordination, with installation details approved by the Modular Service Association.

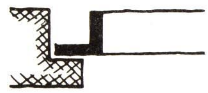
The installation details shown in the following five pages are examples of tried ways to handle some of the most common cases. But, as in all design problems, there is more than one answer; there is no final solution.

Practically all window installation depends on four types of joint (and various combinations of these four):

A. A flange of the window frame is lapped over the edge of the rough opening.

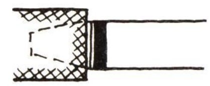


B. The flange is held against a rebate.



C. The flange is held in a groove.

D. The frame is secured by straps or anchors.

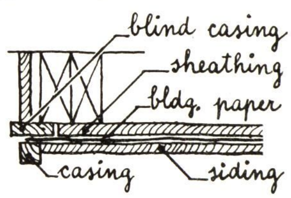


Repeated breaks between inside and out (as in the first three examples above), and continuous elastic gaskets of building paper and caulking give a good weather seal.

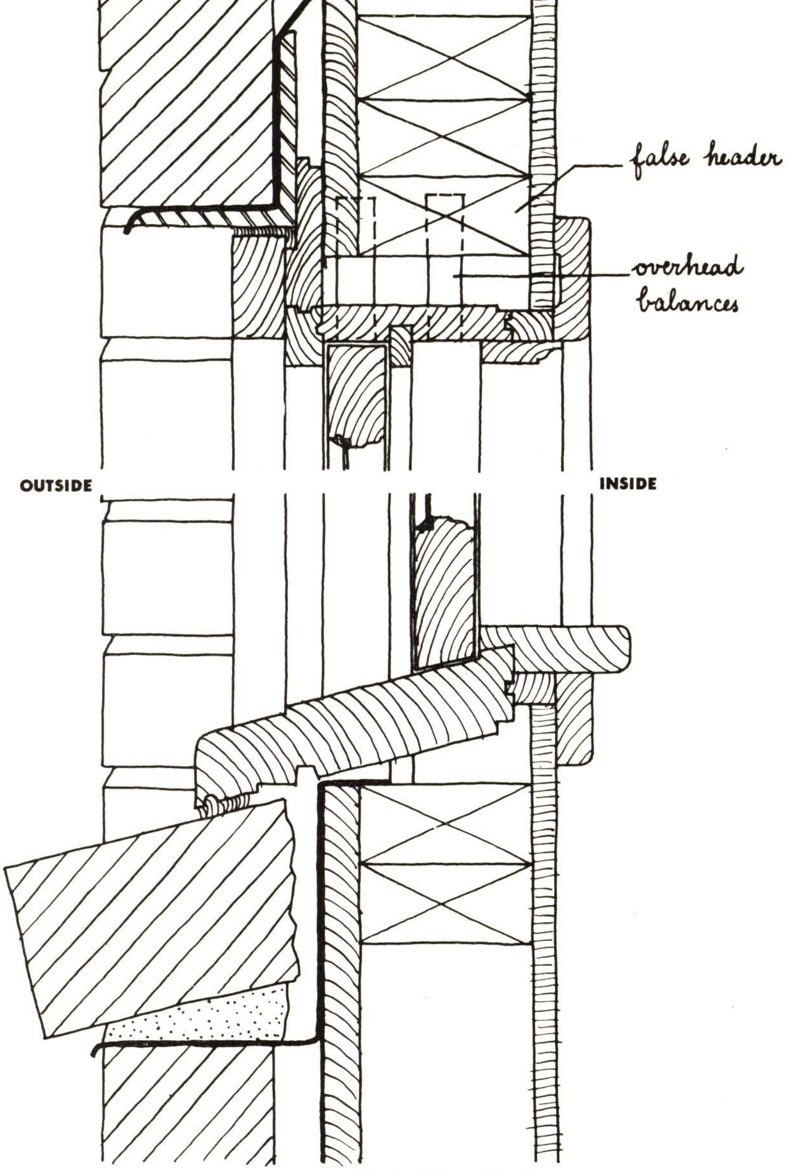
WOOD WINDOWS

Most standard details for wood window installation are based on joints **A**, **B** and **C** illustrated above. The blind casing, or in some cases the outside casing, provides the flange. Details are the same for double-hung or casement, except that double-hung fitted with counterweights or spring balances extending beyond the window frame require additional space (see opposite page).

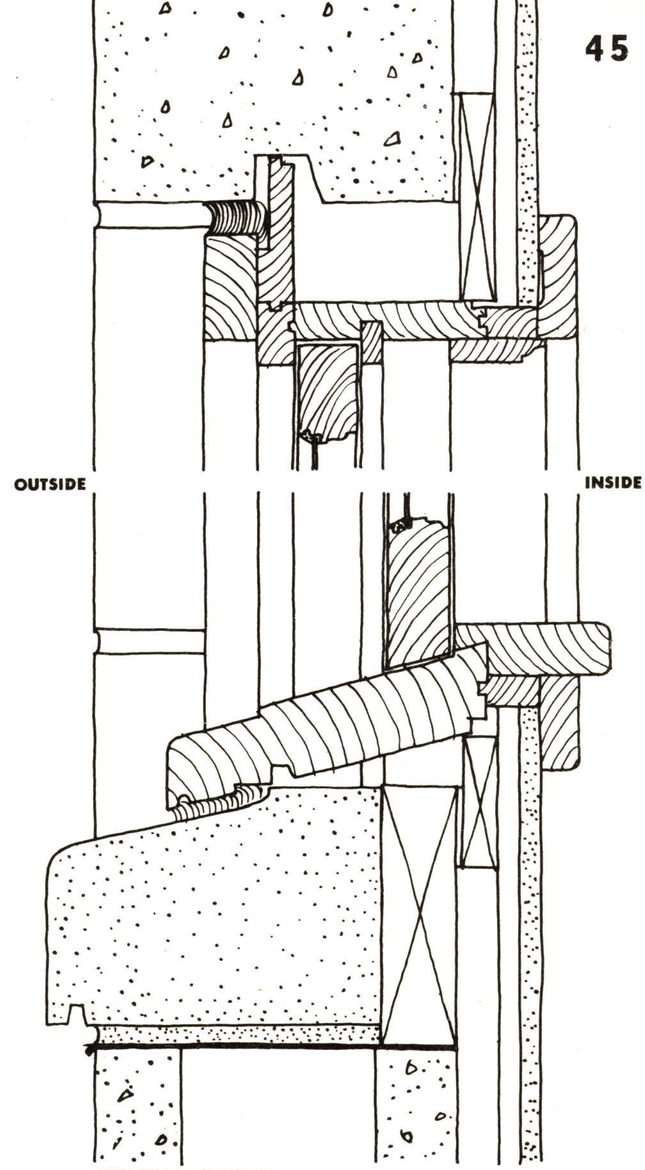
In wood frame construction (this includes installation in brick and stone veneer). Shown on page 33 is a typical example of a double-hung window installed in a wall of wood frame and siding. The installation is based on details supplied by the National Door Manufacturers' Association. The blind casing laps over and is nailed to the framing members at jambs and head. A windbreak strip laps over the header at the sill. The sheathing butts against the blind casing, over which the building paper is carried. This method of installation makes possible a narrow exterior casing—it is simply a stop for the siding—which is often desirable from the viewpoint of appearance. If the casing has been fitted to the frame in the factory, the building paper has to stop against it, as shown on page 33. If the casing is loose, then the building paper may be extended under it, giving added weather protection. This is shown in the detail at right.



On page 32 is shown an installation where the blind casing is practically eliminated, and the window is nailed to the studs through the exterior casing. This short cut can be taken without damaging results because of the accurate construction of the window frame combined with the careful application of building paper seals (for which there is a special pre-cut groove) by the men on the job.

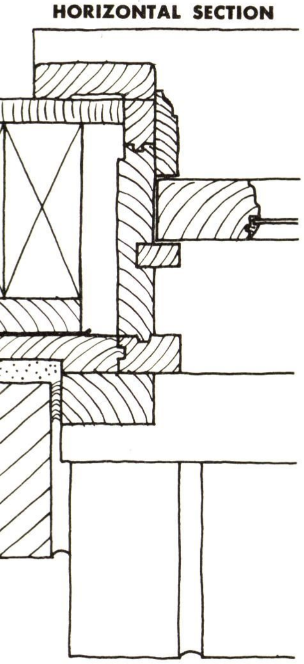


VERTICAL SECTION



VERTICAL SECTION

HORIZONTAL SECTION

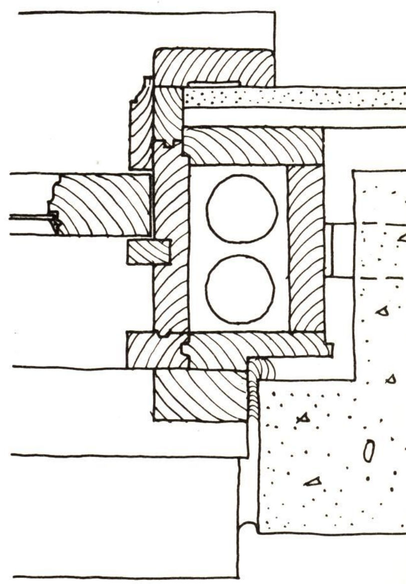


In brick veneer *(left)*. Based on NDMA details, this shows a window with overhead balances. Notice the third header, the so-called false header, at the window head. This is actually a nailing block which is stopped short of the jambs to make room for the balances. In this drawing the blind casing is shown lapping over the sheathing. This gives more interior depth to the window opening, so gives more room for shades or Venetian blinds. In this detail we have shown an interior finish of dry wall construction.

In concrete block masonry *(right)*. Also based on NDMA details, this shows a window equipped with pulley and counterweights. Notice that the weights are enclosed, for protection, in a weight box. This is always done when such a window is installed in a masonry wall.

Installation of wood windows in other types of wall structure follow the same general principles as those already described and shown in these particular examples.

HORIZONTAL SECTION



SCALE: 3"=1'-0" 0 3" 6"

METAL WINDOWS (SOLID SECTION)

We have divided the installation details of metal windows into two parts. The first deals with those Z-shaped solid sections, which are typically (though not exclusively) hot-rolled. The second part, on page 49, includes hollow metal sections of lighter weight and more complex profile, which are normally cold-rolled or extruded.

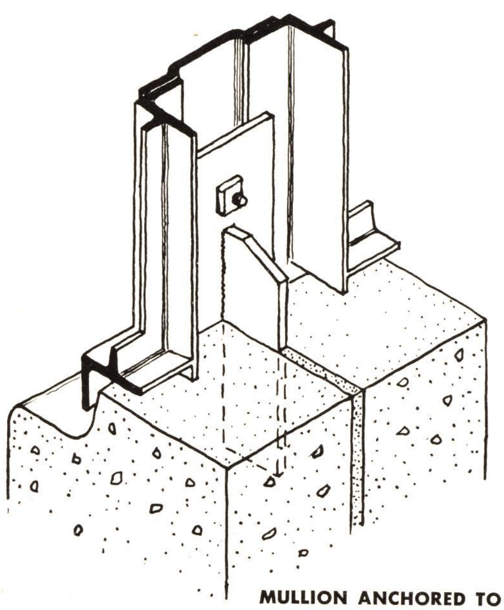
There are three typical shapes to be found in the frame of the standard hot-rolled metal window:

EVEN LEGS

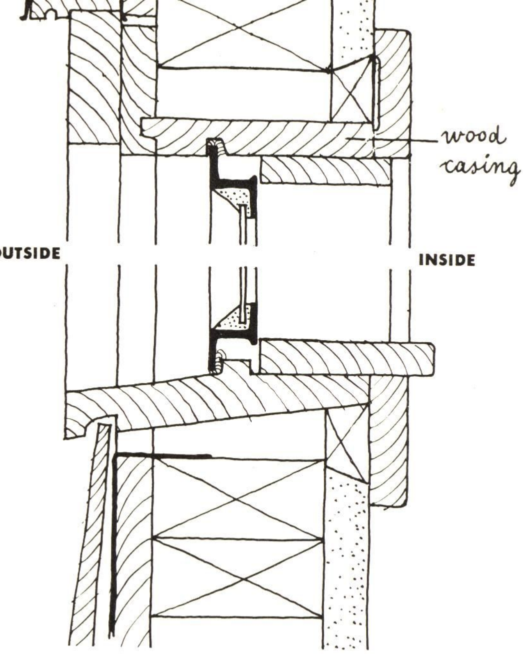
UNEVEN LEGS

ONE LEG ONLY

These sections are seldom sufficient in themselves to provide a satisfactory joint, so they must be supplemented by auxiliary members such as fins, clips, and sub-frames. In the case of a single window unit fastening of the window to the building frame is usually at the jambs. However, in cases where a number of such units are used together, connected to each other by mullions, they are held to the building frame at head and sill. The mullions themselves are usually anchored to the sill (see detail below), except in light windows where they are merely waterproof connectors between the individual units.



MULLION ANCHORED TO SILL



VERTICAL SECTION

1 RESIDENCE CASEMENT WITH WOOD CASING IN WOOD FRAME CONSTRUCTION

In wood frame construction. Narrow metal frames are not well suited for direct connection to wood frame walls. So auxiliary members, such as casings, fins and surrounds, are used. These are supplied by the window manufacturers. Since they are used for installation in non-fireproof walls such members are usually made of wood and can be easily installed in a wood structure. They have the additional advantage of reducing condensation.

1 *Wood casing.* The window is entirely encased in a conventional wood frame and is installed like a wood window. When supplied completely cased and glazed, this is known in the trade as a "package window".

2 *Wood fin.* The drawing shows an installation in brick veneer, but the same principles would apply with any type of siding. The fin corresponds to the blind casing of a conventional wood window. Notice that the fin is dadoed to receive plaster stop.

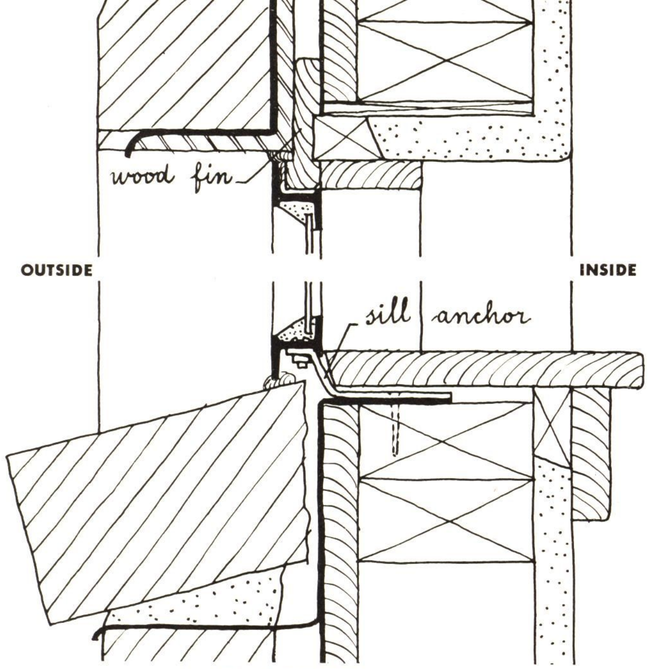
3 *Wood surround.* The surround is a dressier type of fin which also includes a sill member.

In brick masonry

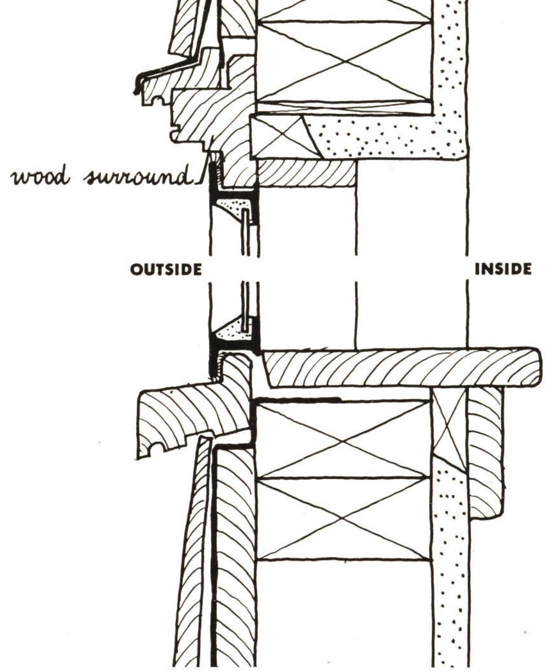
4 *Prepared opening.* The drawing shows installation details for an Intermediate window. The even legs at jamb and head are not sufficient in themselves to hold the window satisfactorily, so the manufacturer adds a steel fin welded to the frame. Notice also how the exterior leg forms a continuous caulking groove.

5 *Built-in.* The exterior leg of the frame, or an auxiliary fin, is held between two courses of brick at the jambs, and between steel angles at the head. The drawing shows a Housing casement. Notice that this window has an extra long leg at head and jambs because it is frequently installed in a wall such as this. Notice, too, the complete steel casing which provides trim and plaster stop.

SCALE: 3"=1'-0" 0 3" 6"

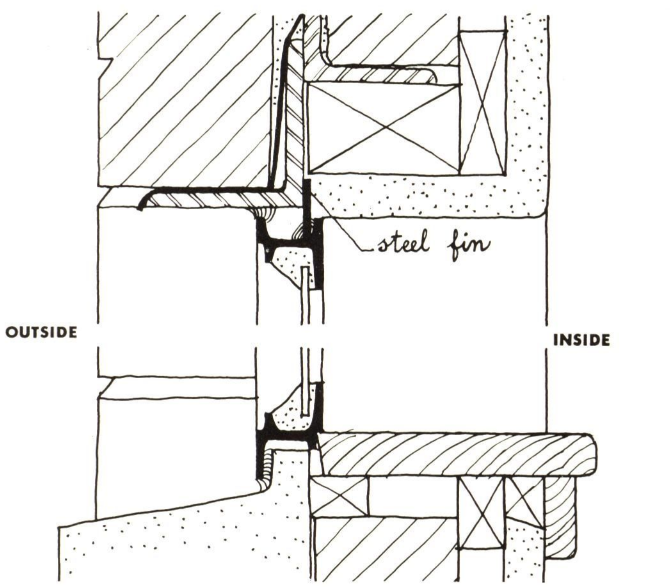


2 VERTICAL SECTION
RESIDENCE CASEMENT WITH WOOD FIN
IN WOOD FRAME CONSTRUCTION

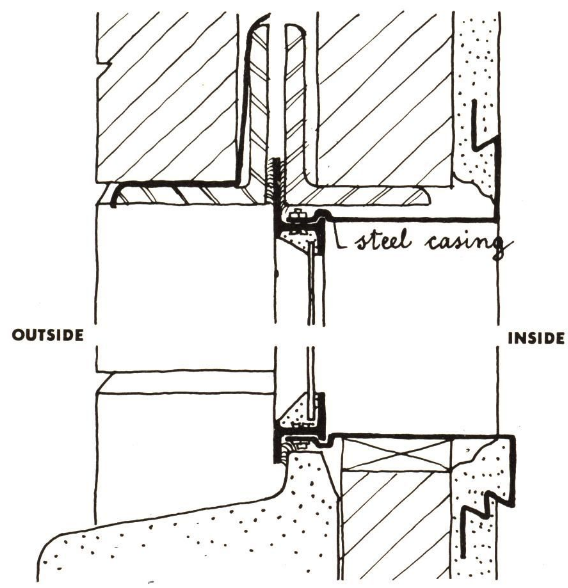


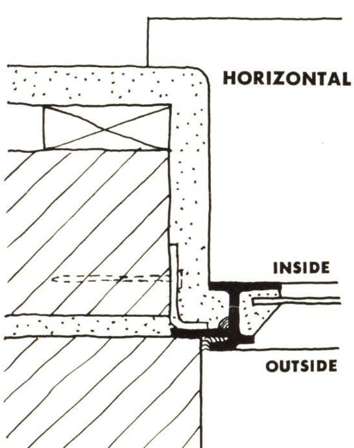
3 VERTICAL SECTION
RESIDENCE CASEMENT WITH WOOD SURROUND
IN WOOD FRAME CONSTRUCTION

4 VERTICAL SECTION
INTERMEDIATE WINDOW IN PREPARED OPENING
IN BRICK MASONRY



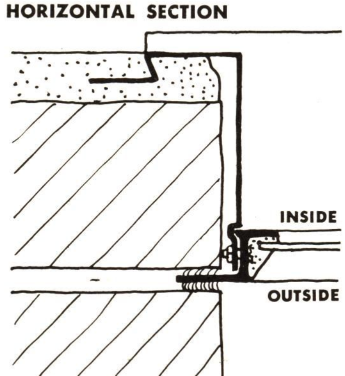
5 VERTICAL SECTION
BUILT-IN HOUSING CASEMENT
IN BRICK MASONRY





HORIZONTAL SECTION

HORIZONTAL SECTION



6 In a concrete wall. The slots at head and jambs are cast with the concrete. To make insertion of the window feasible at least one of the jamb slots must be deep enough that, when fitting the window into the opening, one side can go in deeply enough for the other side, when it is swung around into place, to clear the opposite jamb. The drawing shows an industrial window installed in an unplastered wall. In the case of a furred and plastered wall the installation detail would be similar to No. 4.

7 In stone masonry. The even legs, insufficient to hold the window in a brick wall (see previous page), are satisfactory for installation in a shallow rebate in stone masonry. The fastening of the window is by wood screws in lead shells inserted in holes at the jambs.

8 In exposed steel frame. The window is held by simple clips and strap anchors which allow considerable expansion and contraction of the steel frame without damage being done to the window frame.

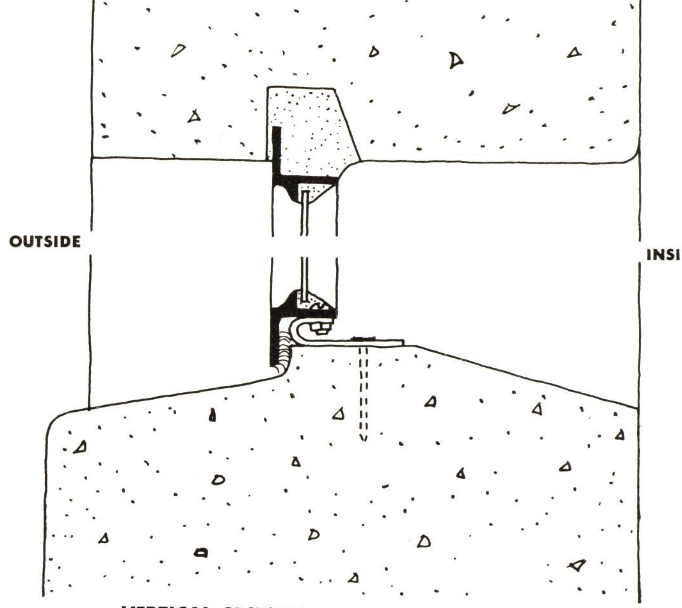
9 In glass block. The channel-shaped joint is dictated by the uncompromising requirements of the glass block. Some windows are built with an integral frame which fits directly over the glass block, others have a special sub-frame, as shown in this drawing.

METAL WINDOWS (HOLLOW METAL)

Cold-rolled, and particularly extruded window frames, due to the process of their manufacture, are better adapted than the solid Z sections to installation in all varieties of wall structure. The window is actually fastened to the wall by anchors of one kind or another. Most of these window frames are designed to fit into a prepared opening. A continuous flange presses against the rebate of this opening on the inside. There is usually, integral with the frame, a continuous caulking groove round the exterior perimeter, and a recess at the sill on the inside to accommodate a wood or stone stool.

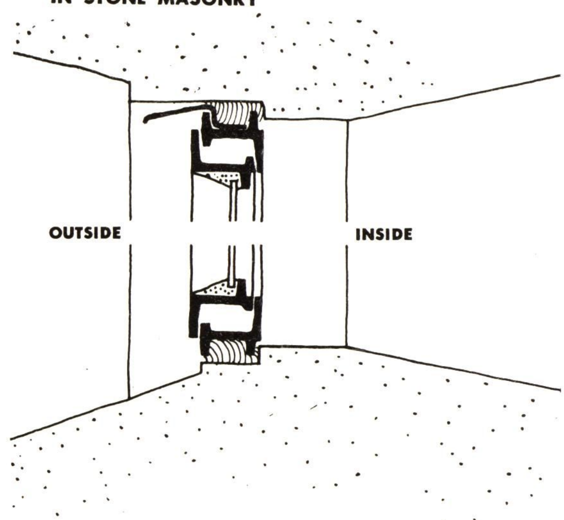
10 In wood frame construction. This aluminum casement window is held by steel anchors which are nailed to the wood frame. To avoid electrolysis and corrosion these anchors are insulated by a heavy coat of zinc chromate pigment in a synthetic resinous vehicle. For weathertightness there is a large caulking pocket all round. A neat little integral cover strip tidies up the joint between window frame and wood trim surround.

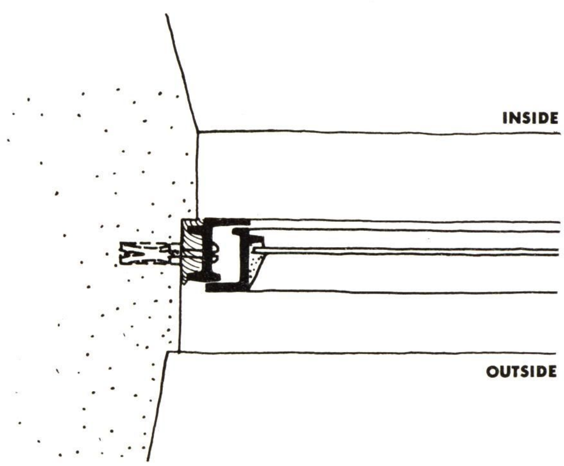
11 In brick masonry. This double-hung window of cold-rolled steel is attached to the structure of the building at the jambs, by means of anchor straps inserted between the brick courses. The inside face of this frame at its end is formed into a plaster stop. A similar jog on the outer face fits over the jamb rebate.



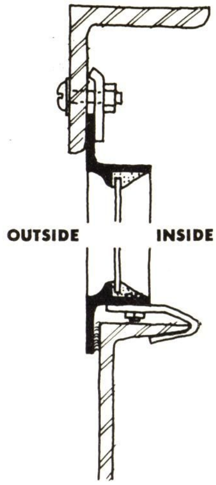
6 VERTICAL SECTION INDUSTRIAL WINDOW IN A CONCRETE WALL

7 INTERMEDIATE WINDOW IN SHALLOW REBATE IN STONE MASONRY

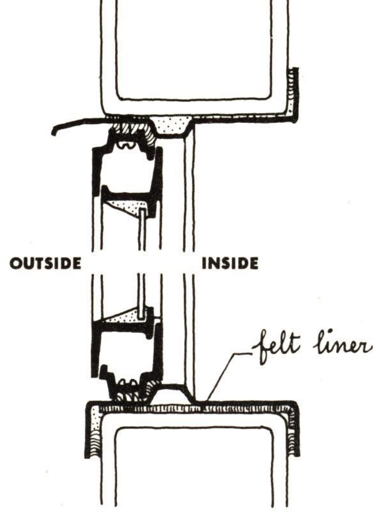




SCALE: 3"=1'-0" 0 3" 6"

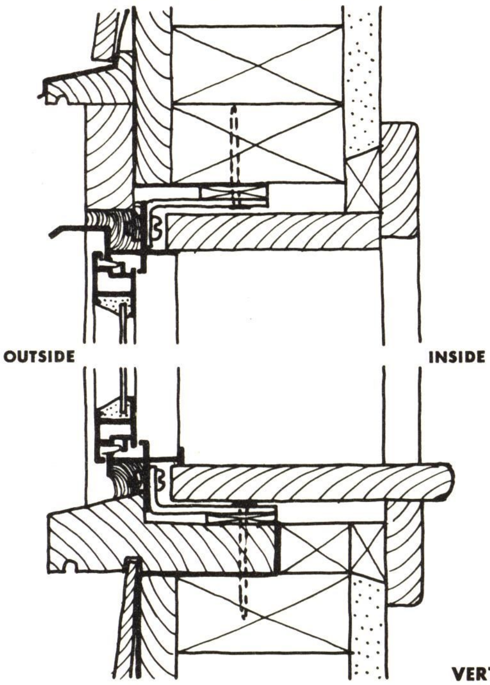


8 VERTICAL SECTION
INDUSTRIAL WINDOW
IN EXPOSED STEEL FRAME

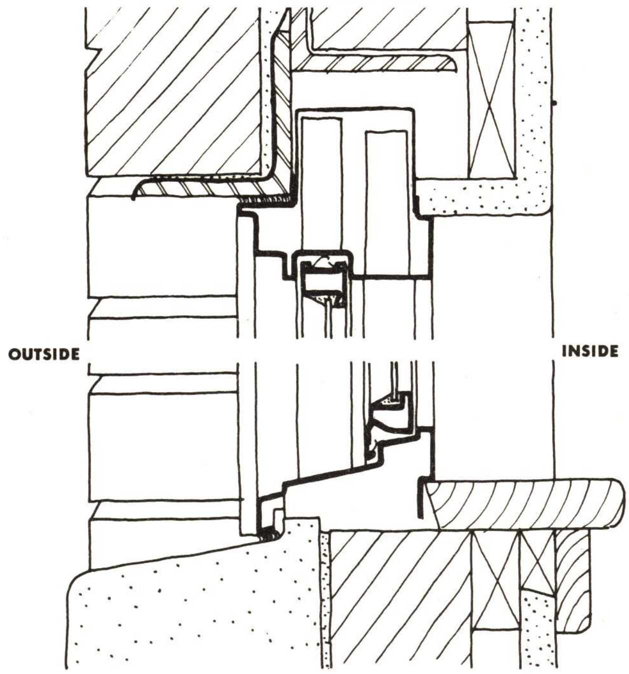


10 VERTICAL SECTION
METAL WINDOW WITH SUB-FRAME
IN GLASS BLOCK WALL

9 EXTRUDED METAL WINDOW
IN WOOD FRAME CONSTRUCTION

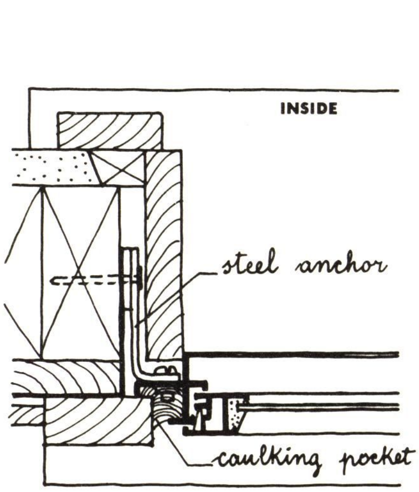


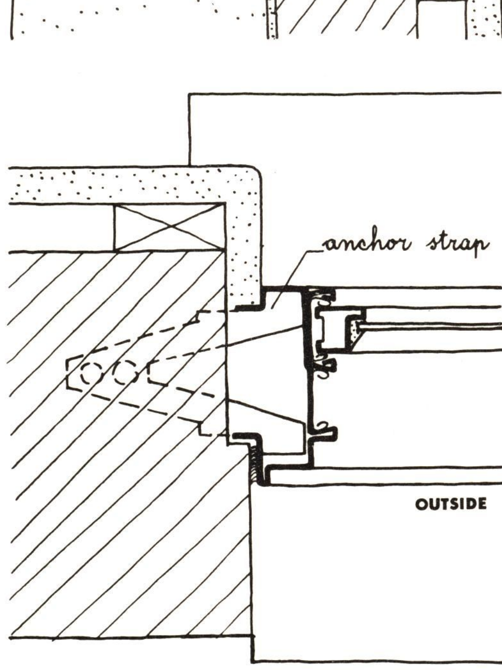
11 COLD-ROLLED METAL WINDOW
IN BRICK MASONRY



VERTICAL SECTIONS

HORIZONTAL SECTIONS





0 3″ 6″ SCALE: 3″=1′-0″

63 BUILDINGS OF SUNDRY TYPES, BY VARIOUS ARCHITECTS, IN DIFFERENT REGIONS, BEING A BROAD SURVEY OF CURRENT THINKING ON FENESTRATION

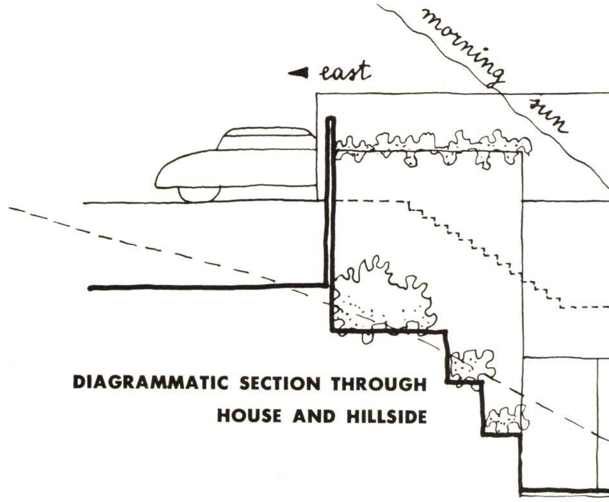
WINDOWS IN USE

EACH JOB COMPLETELY RECORDED WITH PHOTOGRAPHS & CONSTRUCTION DETAILS

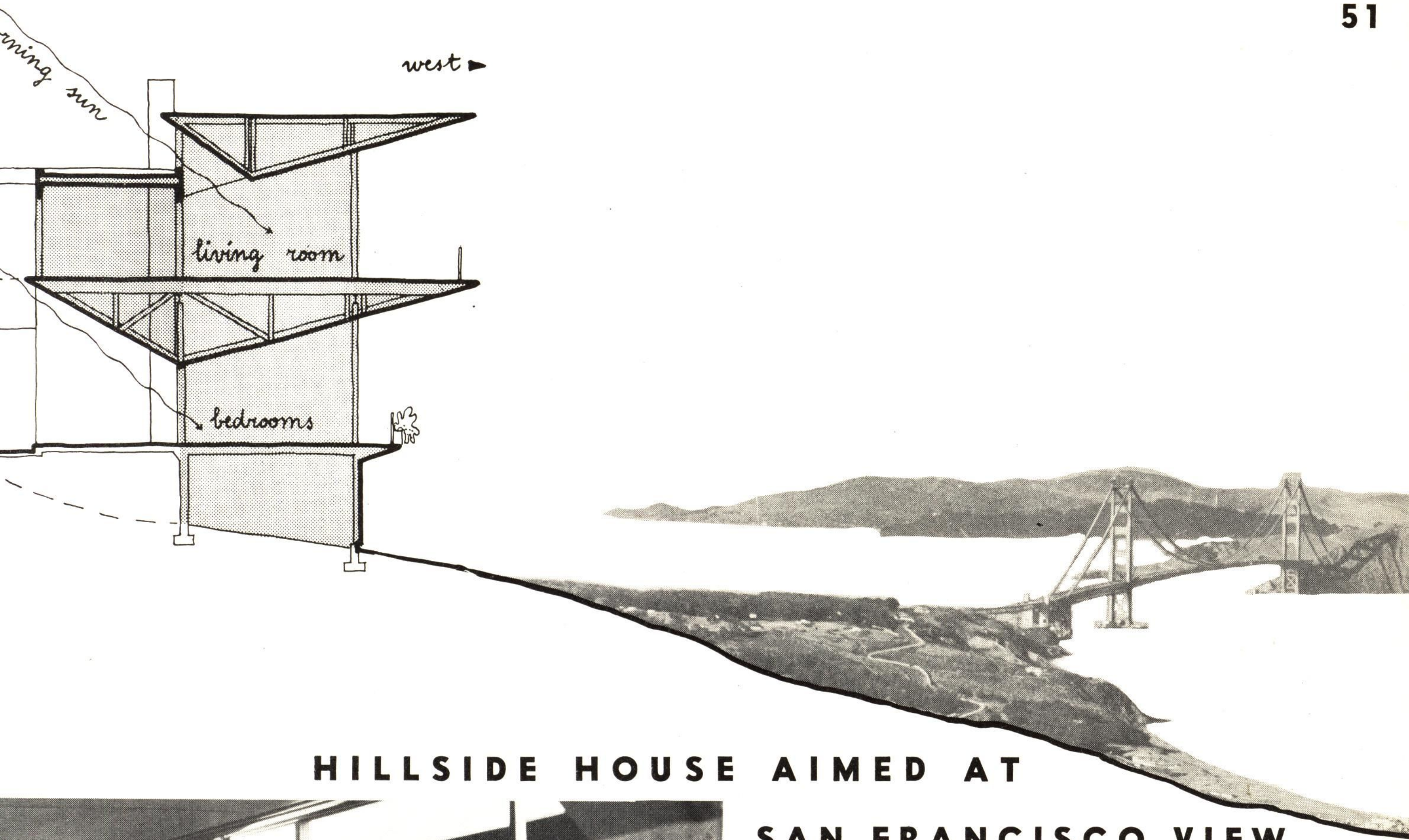
Fenestration controls the daylight entering a building, so that a predetermined amount and quality of light is directed where needed. In this section of the book we shall be discussing lighting design more often than window design. Windows are the ingenious devices by which this lighting design is made to function. Most of the fenestration illustrated in the following pages has been built from the stock parts already described—sash, hardware, weatherstripping, moldings. These parts, however, have often been used in quite unconventional fashion.

The convention of windows sized and positioned according to a historic pattern of facade is fading. The convention of windows doubling as ventilator and light inlet is no longer inviolate, if only because buildings now have much more glass wall than convention would allow, while human ventilation needs remain about the same. Ventilation is being seen at last as a part of heating rather than lighting. This is a change of emphasis as fundamental in its implications for design as the development of built-in heating, which split the functions of the great open fire between furnace, cooking stove and lamps. Now in some buildings illustrated here air-conditioning equipment makes opening sash unnecessary for ventilation. Glass can be fixed, used like any other sheet material as an infilling of the building frame.

Many of the details shown on the following pages are experimental; you will undoubtedly find some of them open to criticism. We shall not attempt to defend them, for there is no single best answer to any problem of design. We do claim, however, that every one of these pages contains some idea of value to any thoughtful reader. If these ideas stimulate others, our purpose will have been achieved.



DIAGRAMMATIC SECTION THROUGH HOUSE AND HILLSIDE



HILLSIDE HOUSE AIMED AT SAN FRANCISCO VIEW

THE WINDOW WALL IS TRANSPARENT EVEN AT NIGHT

The design of this whole structure was controlled by one dominant aim, that its owners might enjoy to the utmost a superb panoramic view of San Francisco and the Golden Gate.

The architect sums it up: "The house does not frame the view; it projects the beholder into it. The view is no mere segment of something seen through a hole. . . . The height above the ground, and the lack of visible connection with it, together with the soaring effect produced by the rising ceilings as they move outward, tend inevitably to lift the beholder into the sky. It is a sky house more than an earth house."

The view being to the west forced the big window walls on to what, from a strictly sun-control viewpoint, would be considered the wrong side of the house. To allow penetration of the more desirable eastern sun, and to give balanced two-directional lighting within the house, the whole structure has been set out from (instead of, conventionally, being built into) the slope of the hill.

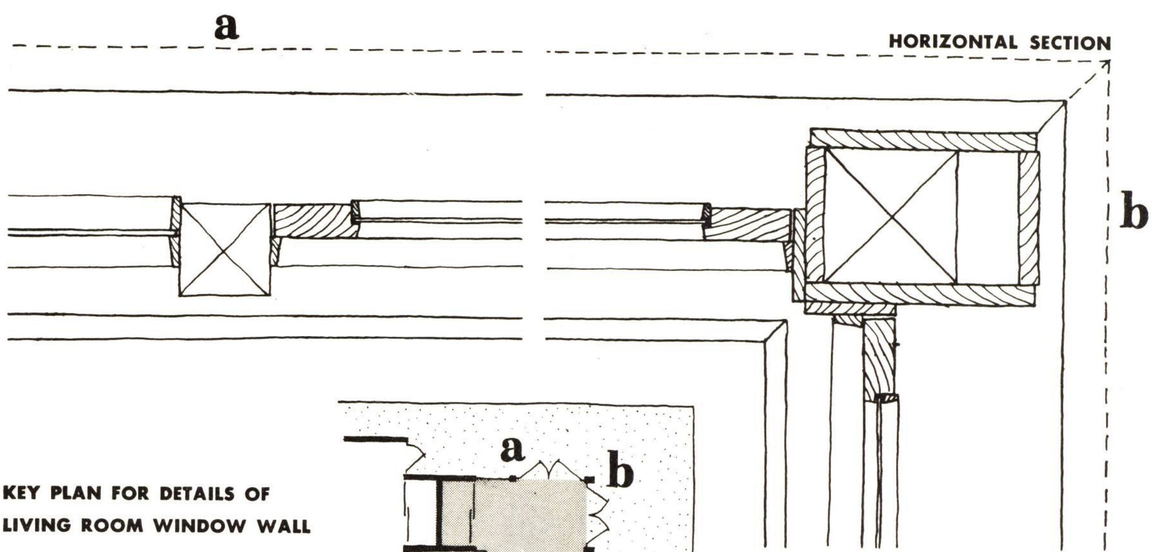
Inverted gables and sharp airfoil edges to the balcony overhangs, accentuate the delicate, poised effect. The classic architectural canons have been literally turned upside down.

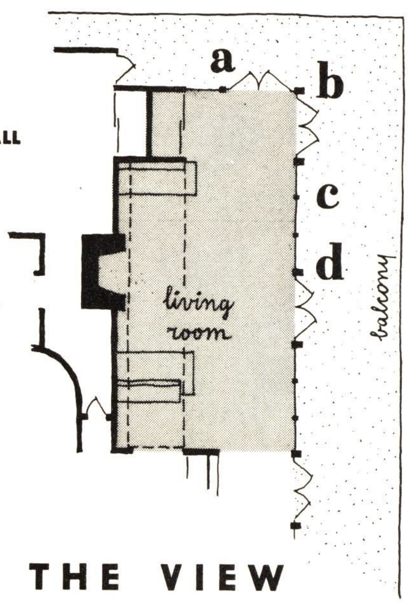
Architect: Harwell Hamilton Harris. *Owner:* Mr. Weston Havens. *Location:* San Francisco, Cal.

MORE PICTURES AND DETAILS OF THIS HOUSE ON THE NEXT FOUR PAGES

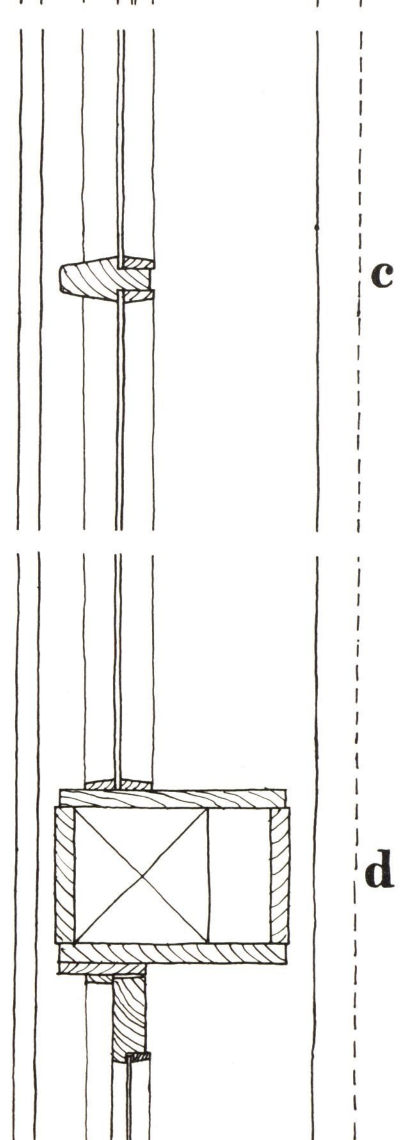
SCALE: 1½"=1'-0"

VERTICAL SECTION





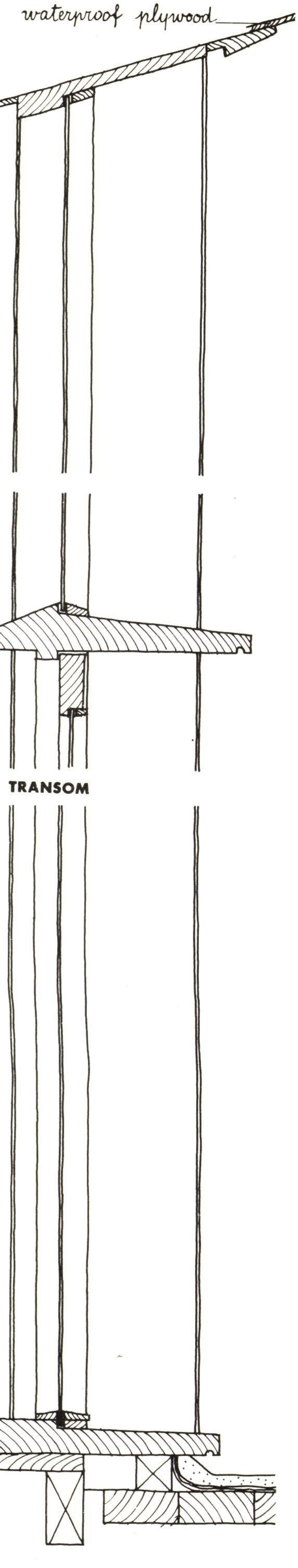
KEY PLAN FOR DETAILS OF LIVING ROOM WINDOW WALL

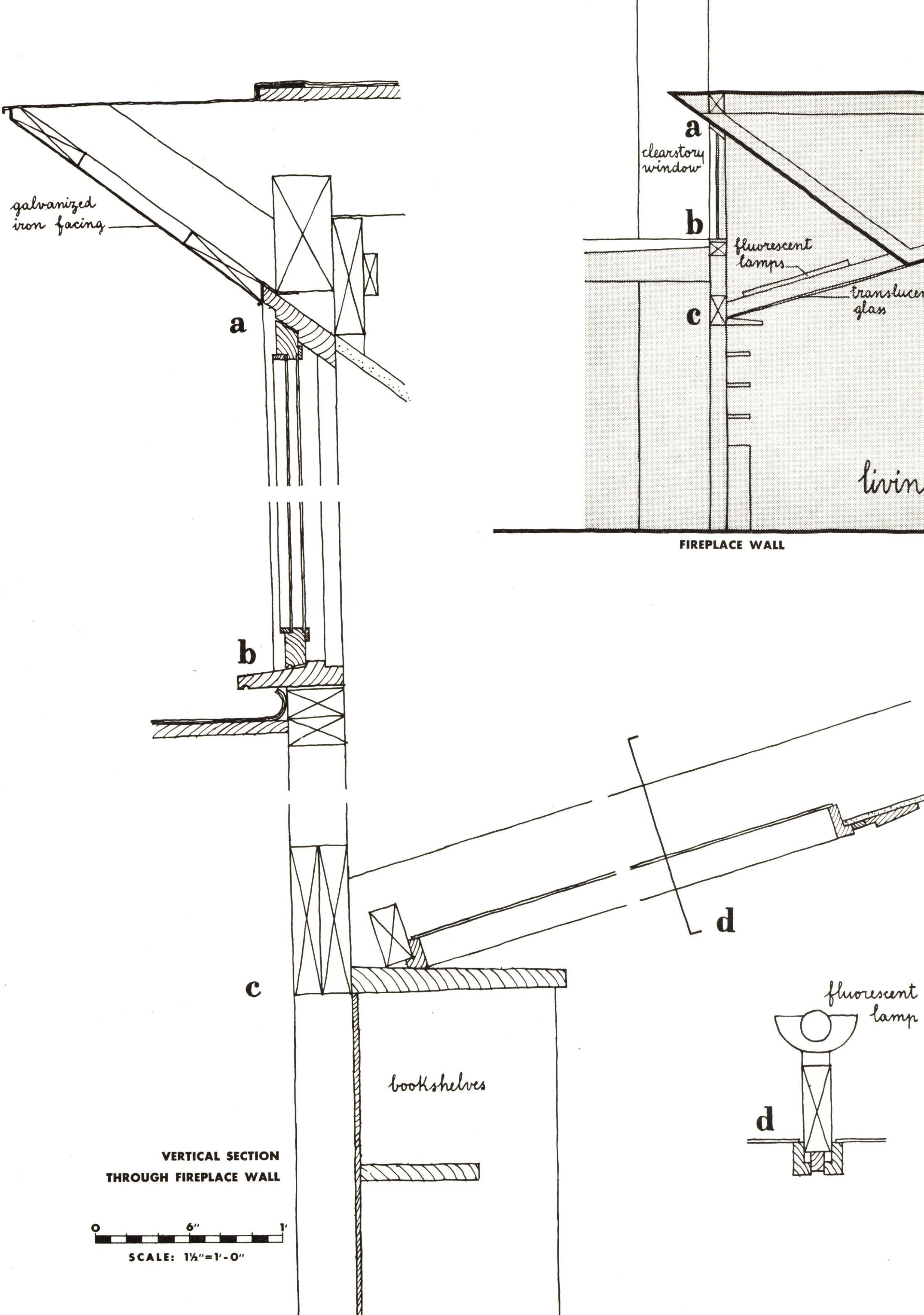


TO LET IN THE VIEW BOTH NIGHT AND DAY

The daylight transparency of a window wall is too often allowed to degenerate at night into a solid bounding wall. This may be of cold, reflective black glass, or covered with a warmer fabric. In either case the airy daytime spaciousness is lost, and the character of the room is transformed (seldom for the better) by an uncalculated change in the direction and quality of lighting.

In the Havens house, where the view of San Francisco is almost more fascinating at night than by day, the essential transparency of the glass walls is retained by indirectly lighting the outside of the glass with floodlights aimed at the soaring overhang.


waterproof plywood
TRANSOM

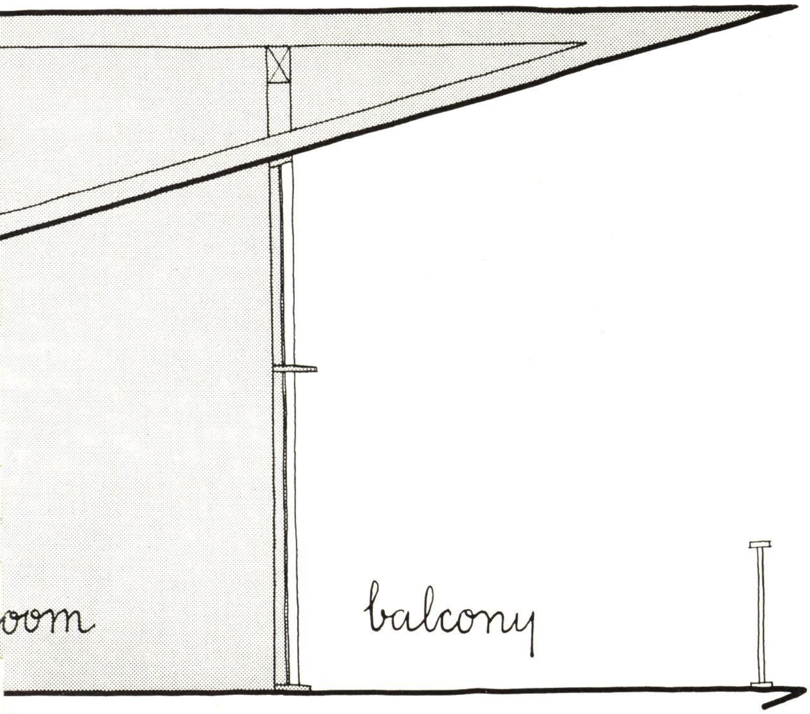


FIREPLACE WALL

VERTICAL SECTION
THROUGH FIREPLACE WALL

0 6" 1'

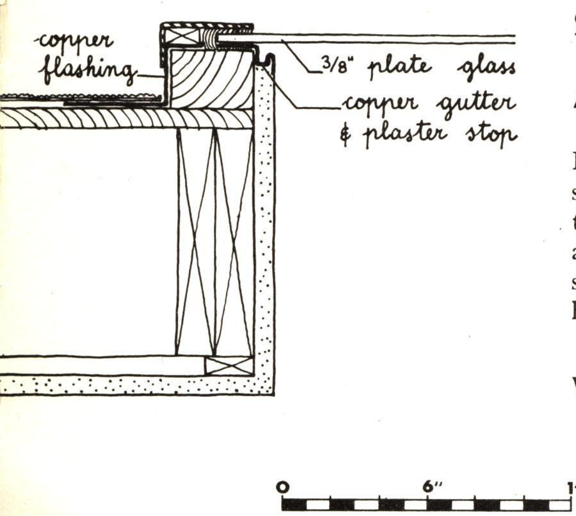
SCALE: 1½"=1'-0"



EQUALIZED LIGHTING

The fireplace—eastern—wall of the Havens House living room (cf. the complete house section, page 51) centers on a hearth surrounded by bookshelves, flanked by cupboards and built-in couches. The ceiling above is of translucent glass admitting daylight from a clearstory window. After dark the daylight is replaced by the light of fluorescent tubes set on the ceiling joists directly above the skylight. Light from this skylight prevents the fireplace wall appearing too dark in contrast with the brightness of the window wall opposite. Also, since natural and artificial light both come from the same direction (see pages 52, 53 for artificial lighting of the window wall), illumination is always equalized.

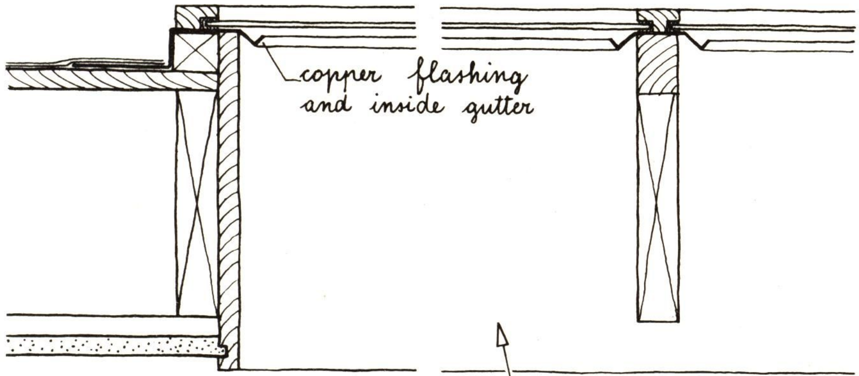
LIVING ROOM OF THE HAVENS HOUSE. WINDOW WALL AT RIGHT



SKYLIGHT IN HALL ADDS LIGHT, HEIGHT

For lighting the interior of one-story houses the skylight is gradually coming into its own, freeing the plan from its binding search for outside wall. It also helps to balance the light intensity between space in the center and on the perimeter of the house, the latter area intensely lit by window walls.

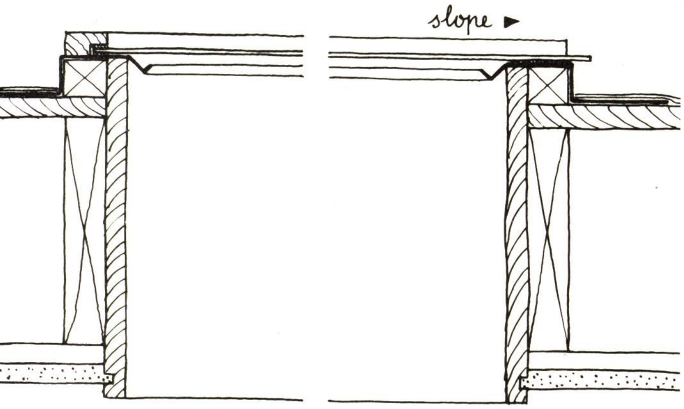
Architect: Edward D. Stone. *Location:* Old Westbury, L. I., N. Y. *Owner:* Mr. A. C. Goodyear.

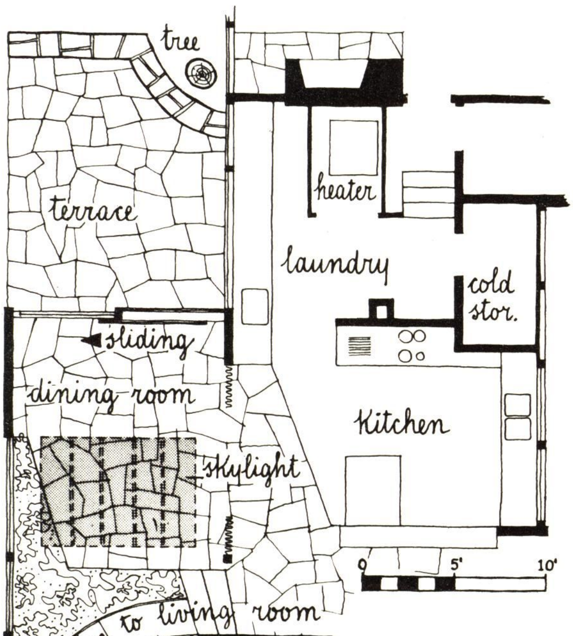


SECTIONS, AS MARKED, THROUGH SKYLIGHT

0 6" 1'

SCALE: 1½"=1'-0"



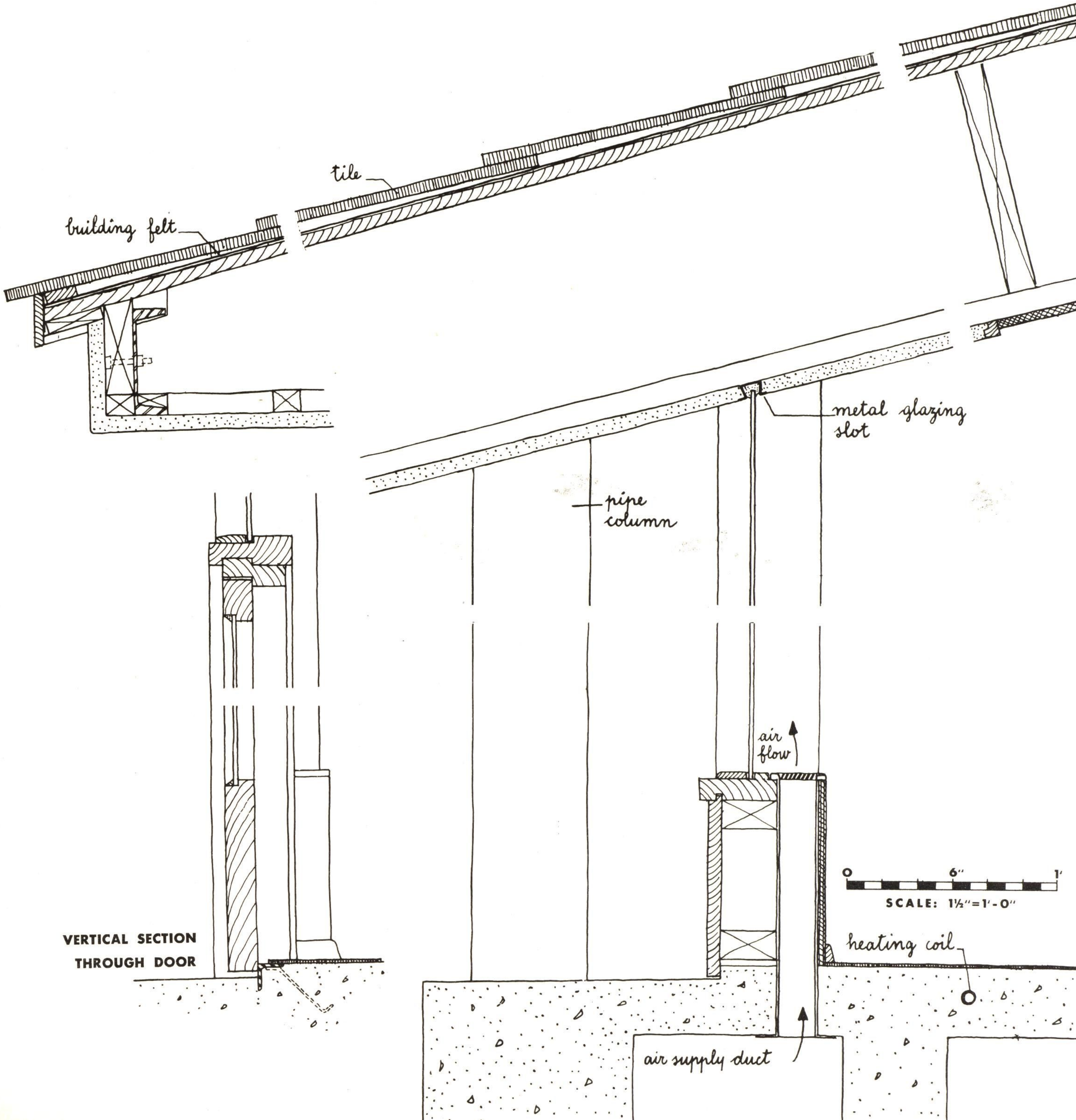


PLAN TO SHOW RELATION BETWEEN DINING SECTION, KITCHEN SECTION, AND OUTDOOR TERRACE

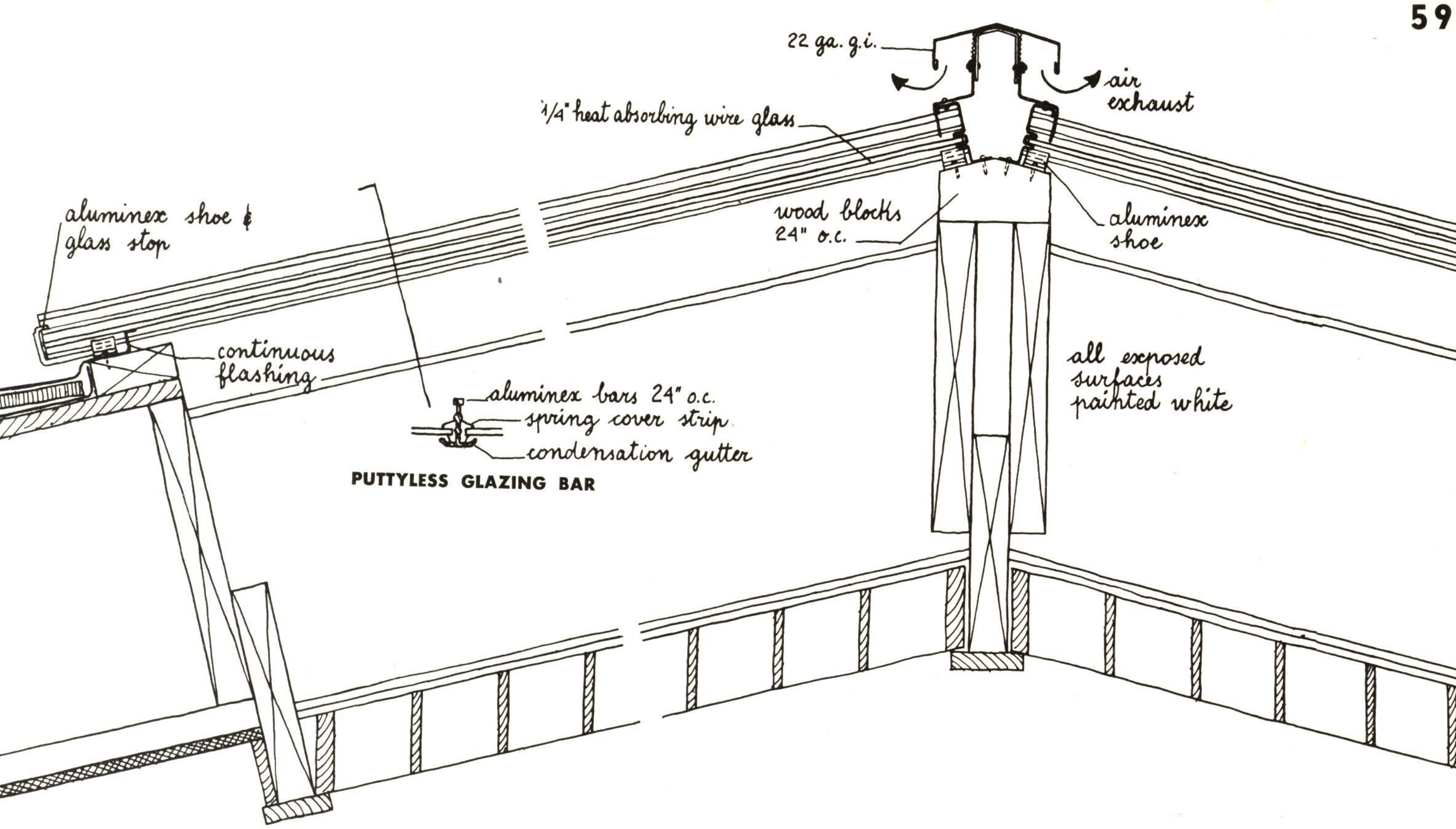
DINING ROOM OPEN TO SKY AND GARDEN

Realizing that the New England climate is all too seldom in sympathy with outdoor eating, this architect has opened his dining room to the sky (by a glass roof) as well as to the terrace (by sliding glass doors). Such a skylight is simply achieved, by leaving the rafters bare, replacing the opaque roofing with sheets of glass, set at a slight pitch so that condensation will drain to one end, not drip. Construction details are also simple: the flashing carried through and bent up inside to form a gutter for condensation and any slight leakage. Here the plaster is stopped at the edge of the skylight box.

Architect: Carl Koch (his own house). *Location:* Snake Hill, Belmont, Massachusetts.



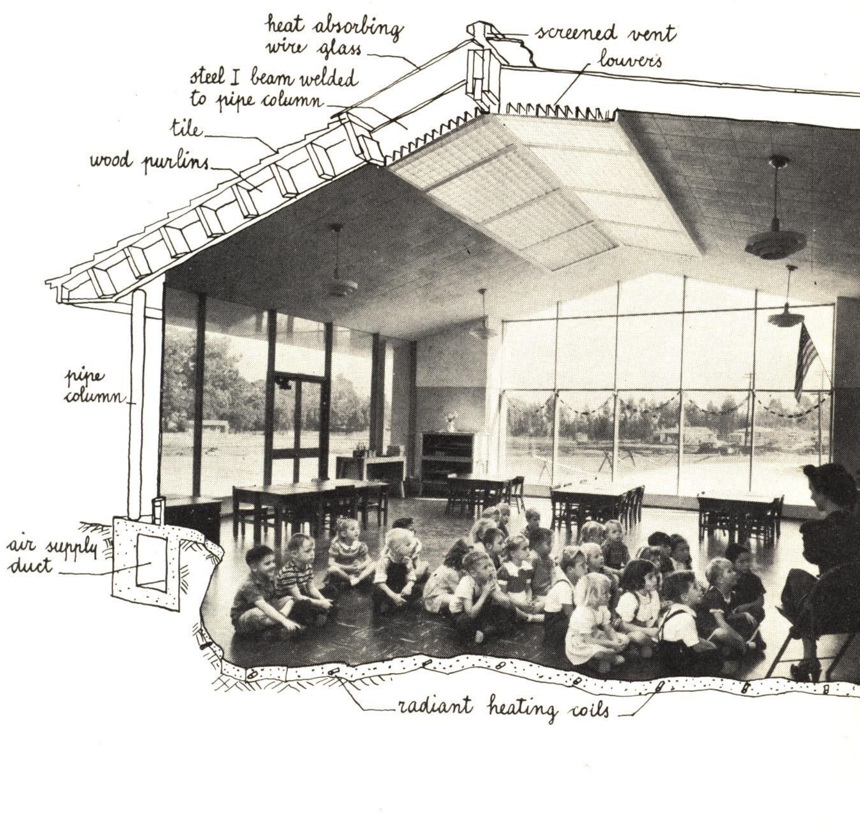
VERTICAL SECTION THROUGH DOOR



LOUVERED SKYLIGHT FOR EVEN LIGHTING

A louvered skylight, combined with floor-to-ceiling windows on the north, clearstory windows above a corridor on the south, and a glass wall to the east, makes for exceptionally even illumination throughout this one-story California schoolroom. The skylight is of heat-resisting wired glass held, without putty, in extruded aluminum glazing bars. It runs the whole length of the roof, which is supported by steel I beams 16 ft. o.c. welded to pipe columns set outside the wall face. Between the I beams (except at the peak, where the roof is glass, the ceiling egg-crate wood louvers) is a grid of wood purlins forming a core for roof and ceiling materials. Fresh air, heated when necessary to supplement the radiant-heating floor coils, is introduced at the base of the window, exhausted through a screened, galvanized iron vent at the roof peak.

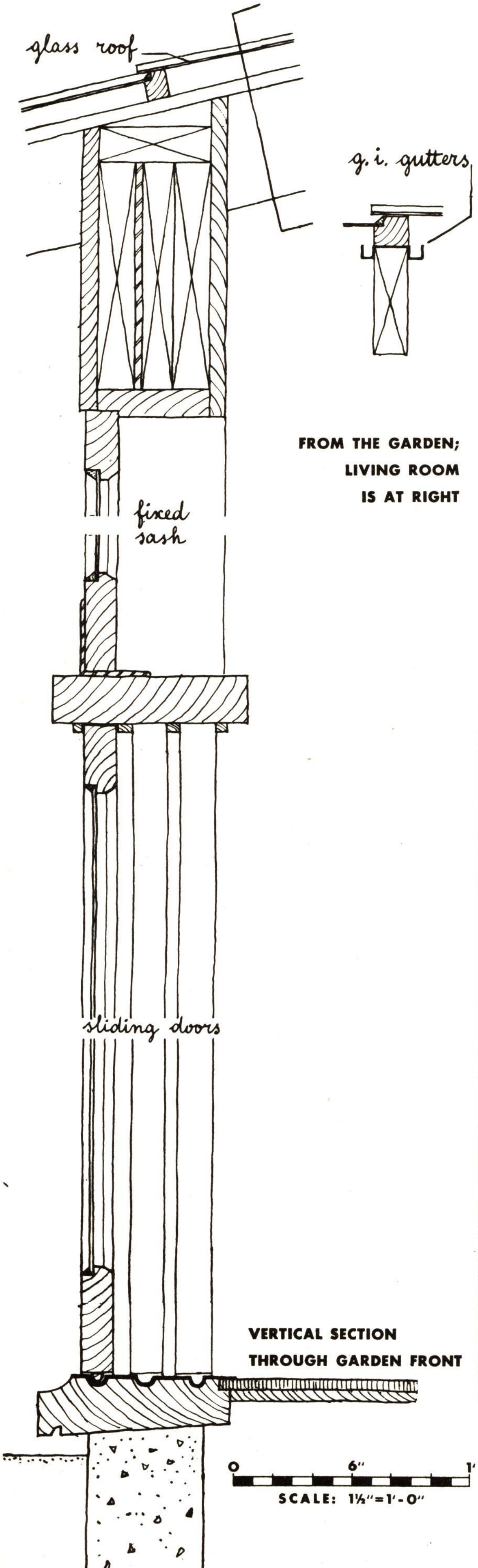
Laurel Creek School, California. *Architects and Engineers:* Franklin, Kump & Falk.



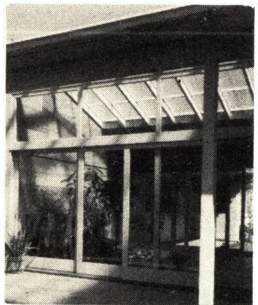
GLASSED-IN ROOM AS PLAN BREAK

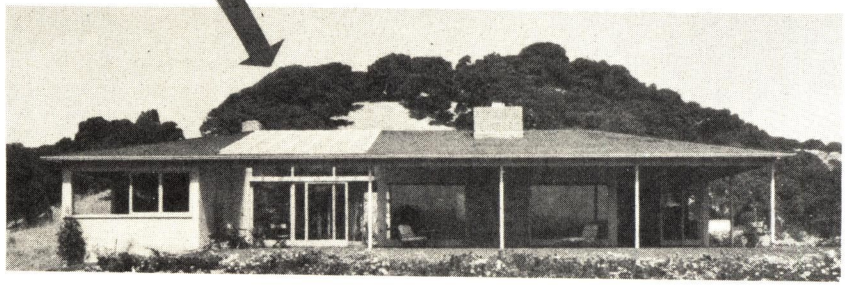
Enclosed by sliding glass doors, roofed by overlapping glass panes, cutting through the whole thickness of the house, this room gives a three-dimensional division between living and sleeping quarters, yet also a weatherproof passage when needed. The general lines of the building, its frame, continue through unbroken; but in this section glass replaces the solid infilling.

The Manor House. *Architect:* W. W. Mayhew. *Location:* Contra Costa County, California.

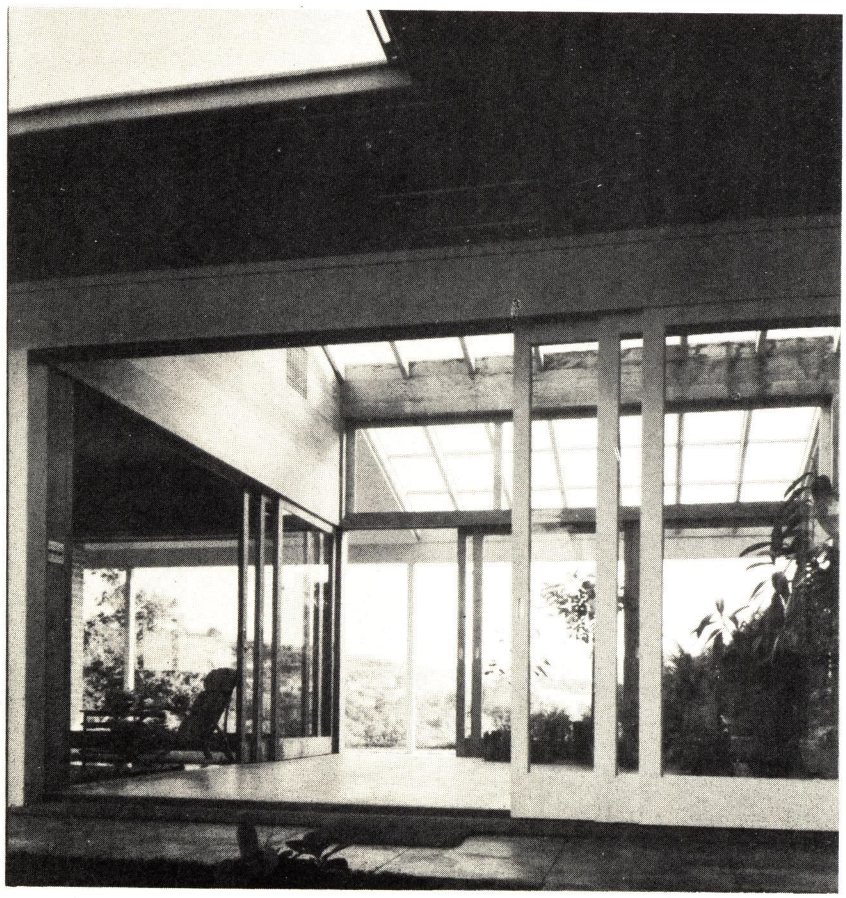


VERTICAL SECTION THROUGH GARDEN FRONT

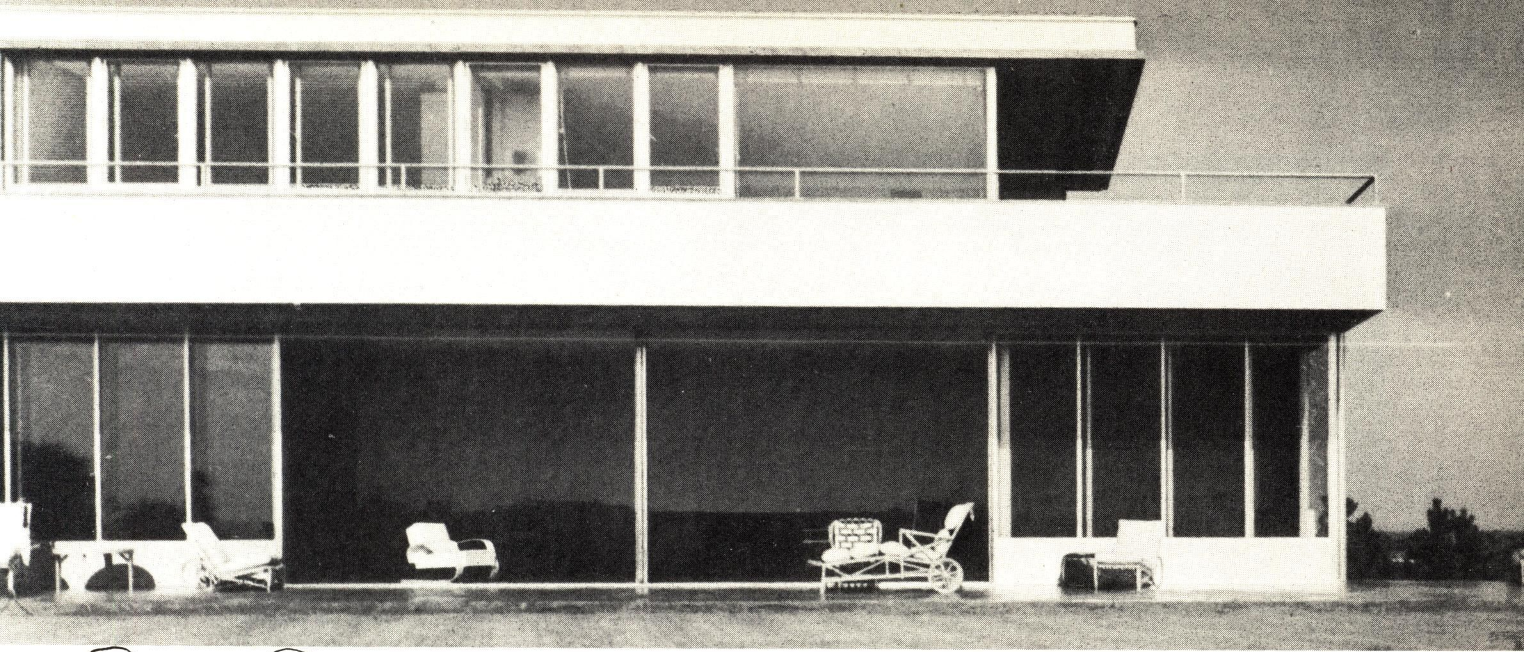




FROM THE GARDEN; LIVING ROOM IS AT RIGHT



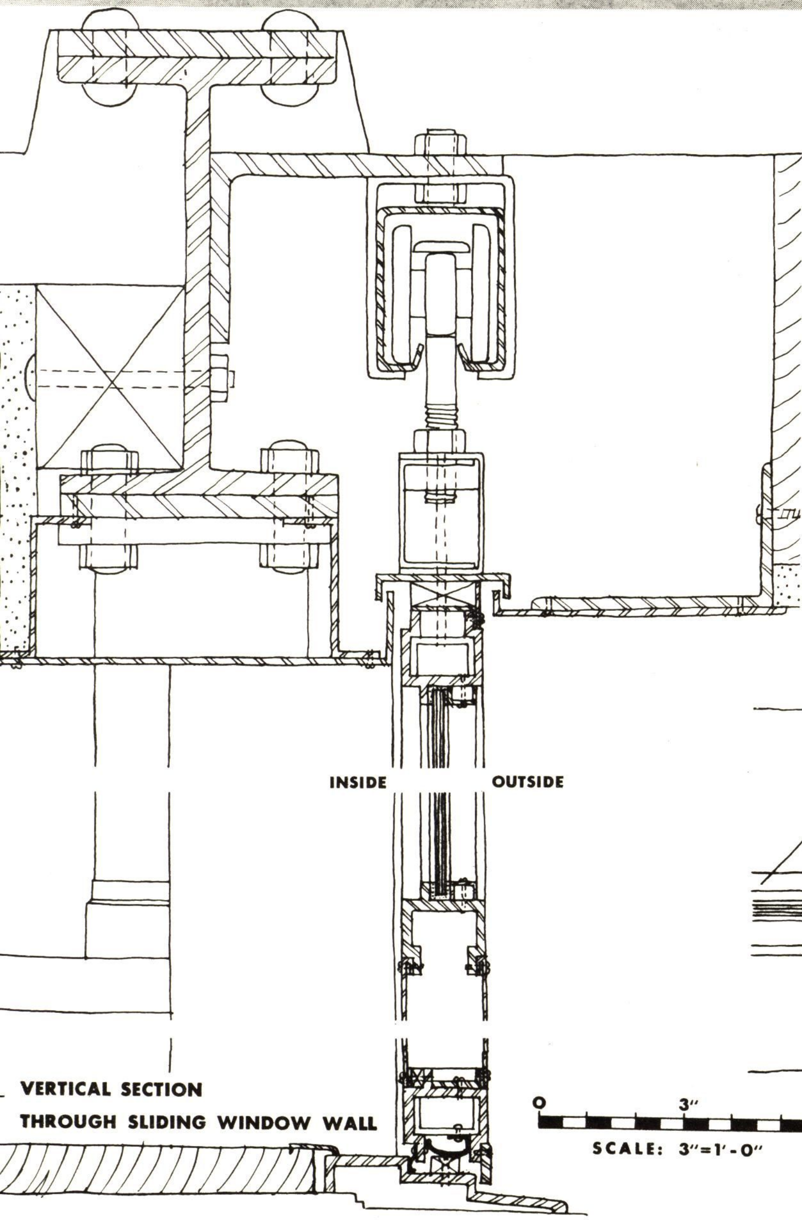
FROM THE ENTRANCE COURT. SLIDING DOORS TO LIVING ROOM AT LEFT



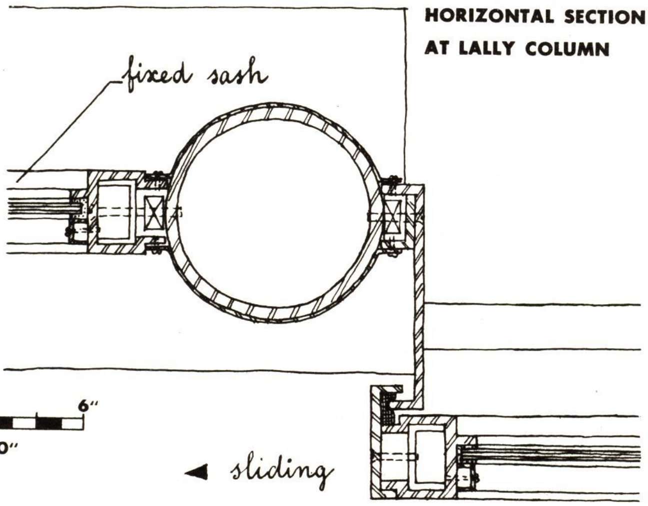
SLIDING GLASS WALL IN SEASIDE HOUSE

A very appropriate use of the sliding glass wall. The glass is framed in extruded aluminum, and then suspended from roller tracks attached to the steel I-beam which spans this wide opening. The balcony above acts as sunshade and weather protection.

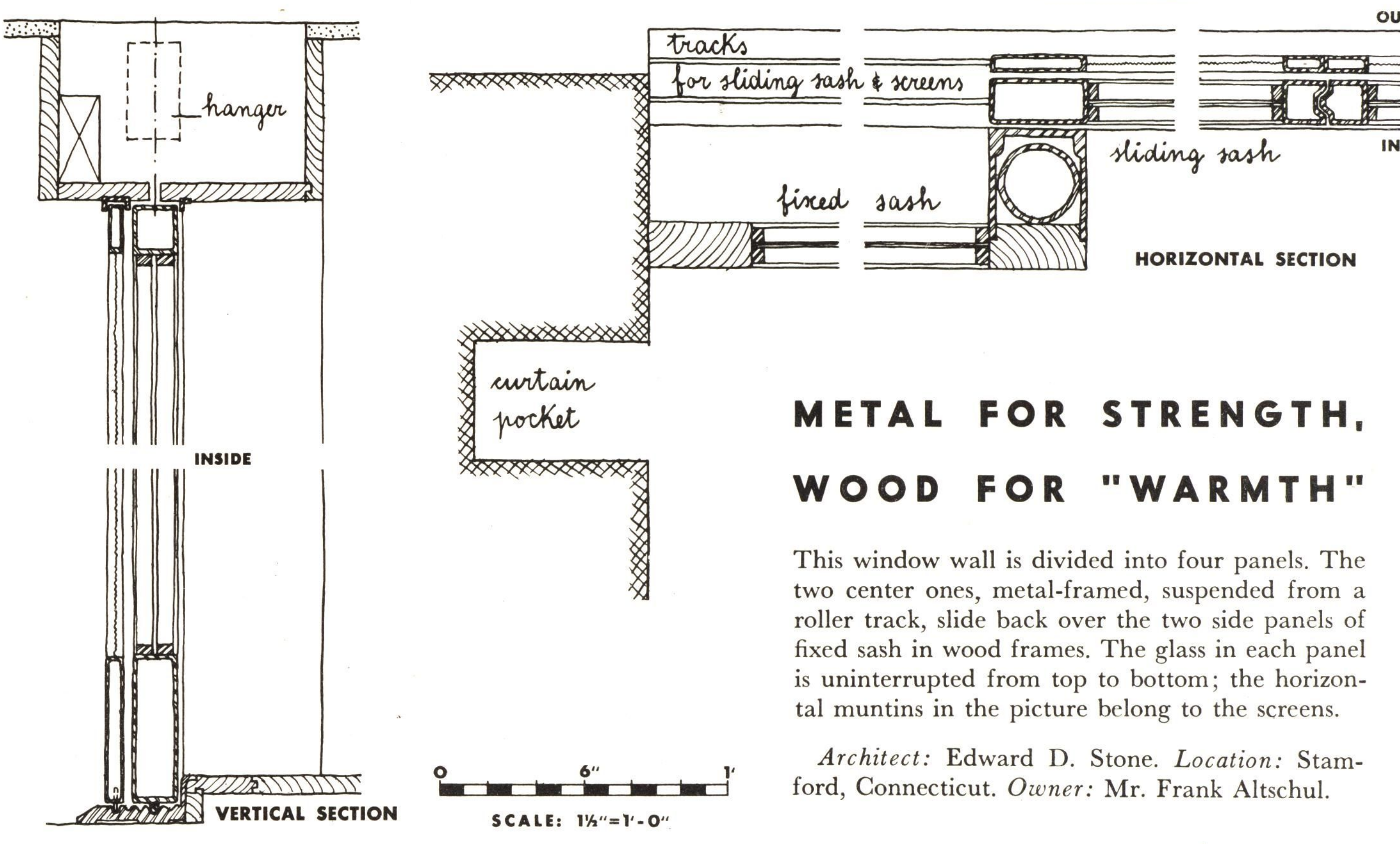
The John N. Brown House. *Architect:* R. J. Neutra (P. Pfisterer, collaborator). *Location:* Fishers Island, N. Y.



VERTICAL SECTION THROUGH SLIDING WINDOW WALL



HORIZONTAL SECTION AT LALLY COLUMN

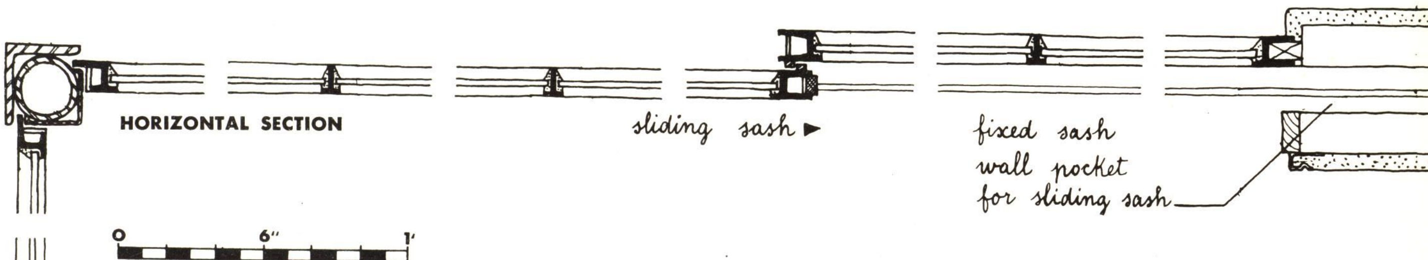


METAL FOR STRENGTH, WOOD FOR "WARMTH"

This window wall is divided into four panels. The two center ones, metal-framed, suspended from a roller track, slide back over the two side panels of fixed sash in wood frames. The glass in each panel is uninterrupted from top to bottom; the horizontal muntins in the picture belong to the screens.

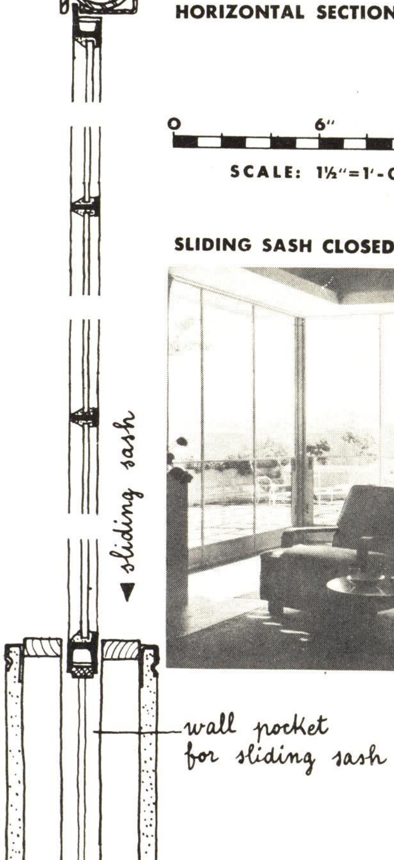
Architect: Edward D. Stone. *Location:* Stamford, Connecticut. *Owner:* Mr. Frank Altschul.

SLIDING SASH OPEN

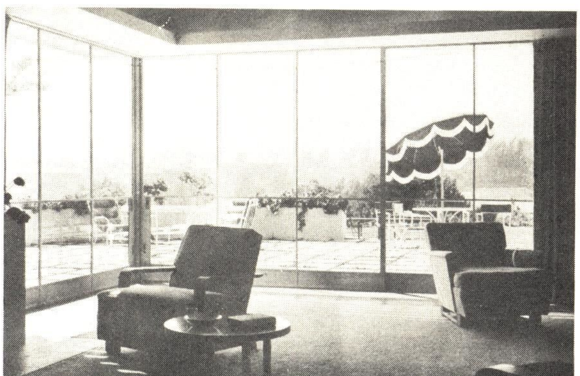


HORIZONTAL SECTION

SCALE: 1½"=1'-0"



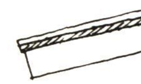
SLIDING SASH CLOSED



MUNTINS SUGGEST DADO, BASEBOARD

The placing of these elegantly thin muntins (standard solid metal sections), suggest the traditional wall division by dado and baseboard, retains more feeling of shelter than many window walls. The two sliding panels, suspended from roller tracks, can be pushed back into wall pockets.

The Stothart House. *Designer:* J. R. Davidson. *Location:* Santa Monica, California.

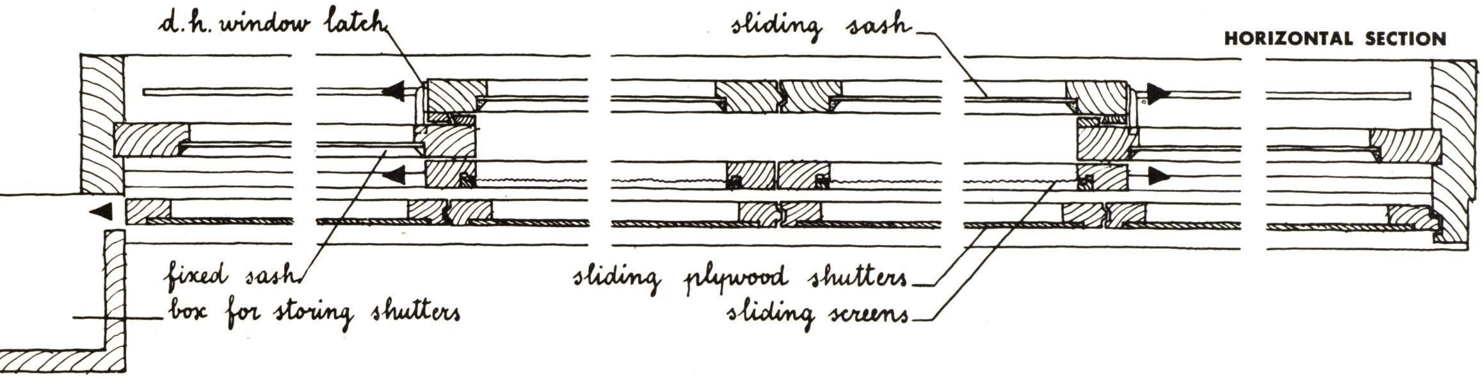


SLIDING SASH : ECONOMICAL NEW IDEAS

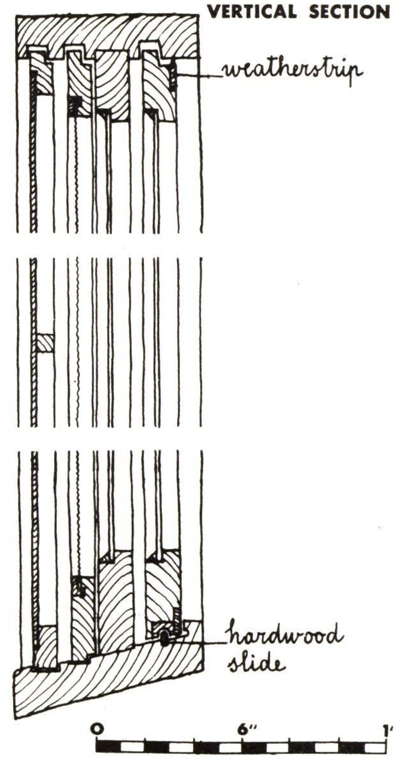
Shown on this and the opposite page are two ingenious and economical new ideas in horizontal sliding sash. Both are by Antonin Raymond, an architect who is an expert in such windows. Both are of simple wood sections, both use inexpensive, standard weatherstripping and hardware. The small ones run on hardwood slides, the large ones have buried sheaves running in brass tracks on the sill. The installation below is in a seaside house at Montauk, Long Island, N. Y. The exterior plywood shutters slide into a box by the side of the window opening for storage. When the house is to be closed they are ready to be quickly drawn across and fastened on the inside. The photo shows a smaller version of the complete window shown in the drawings; both are identical in detail.

In the remodeled Pennsylvania farmhouse (the architect's own home) shown opposite, a continuous wall of floor-to-ceiling sliding windows has been projected out beyond the posts of the original building frame. A wide roof overhang is for protection from sun and weather. To avoid any obstruction in front of the windows, radiators have been set below floor level; the heat rises through inconspicuous wooden grilles set flush with the finished floor surface.

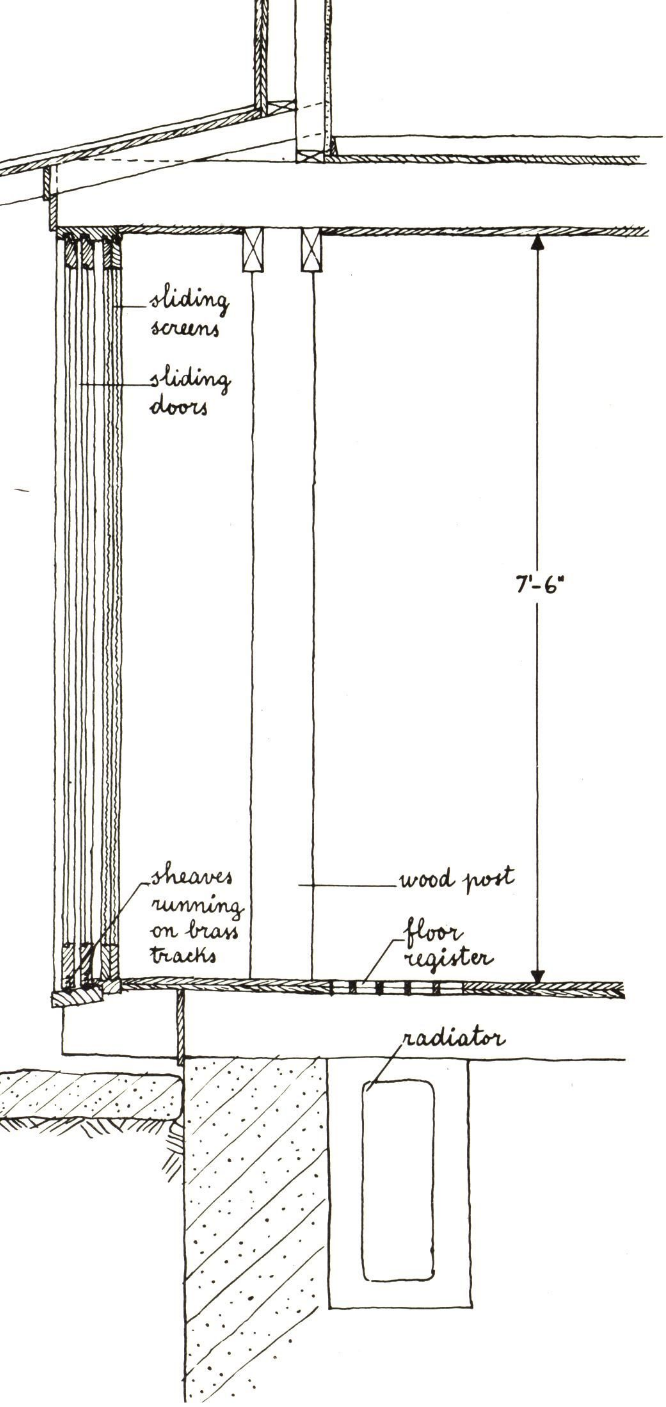
HORIZONTAL SECTION



VERTICAL SECTION

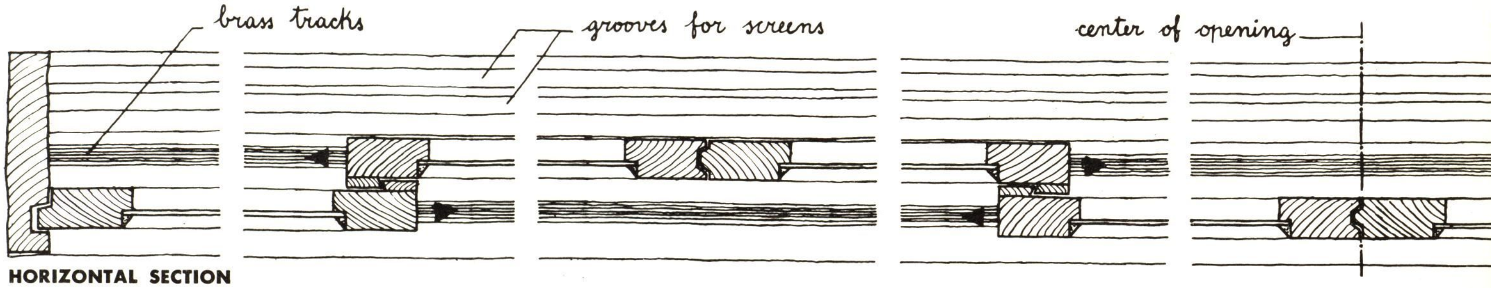


SCALE: 1½"=1'-0"

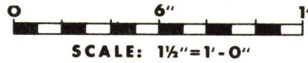


VERTICAL SECTION
THROUGH WINDOW SIDE OF ROOM

REMODELED FARMHOUSE WITH CONTINUOUS WINDOWS PROJECTED BEYOND FRAME



HORIZONTAL SECTION



SCALE: 1½"=1'-0"

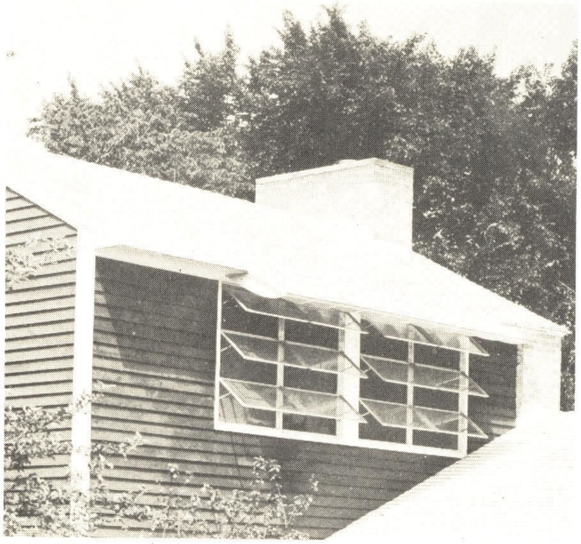
THE PATTERNS OF STANDARDIZATION

The imposing pattern of the rural office building shown at right is dependent upon the most economical standardization in the units which together compose the facade. The sash — top-hung with a projected hinge where ventilation was needed, elsewhere fixed—is of the simplest possible type. So are the gay, coral-painted sunshades, with a slot left between the solid shade and the face of the building to prevent hot air being pocketed underneath against the windows. And the fitting together of all these elements has been so carefully considered that all the horizontal connecting members are of uniform section (see detail drawing opposite).

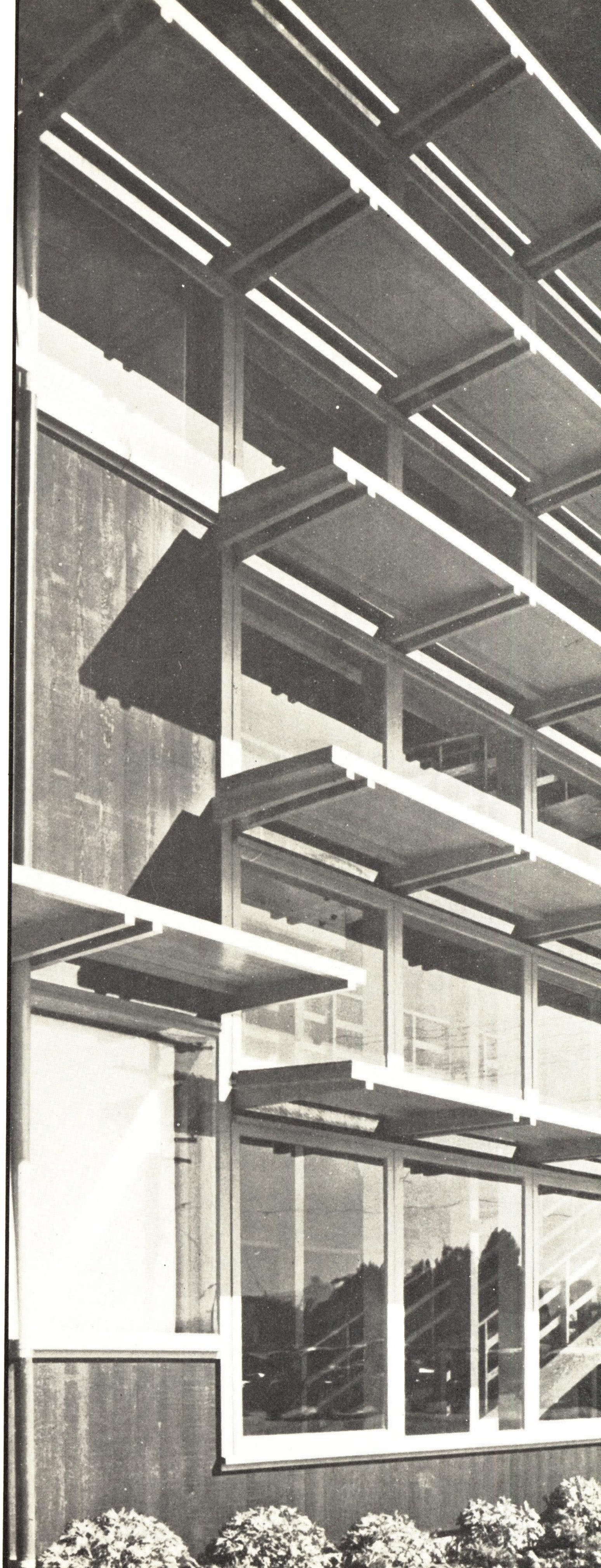
Architects: Wurster, Bernardi & Emmons. *Location:* Sunnyvale, Cal. *Owner:* Schuckl Canning Co.

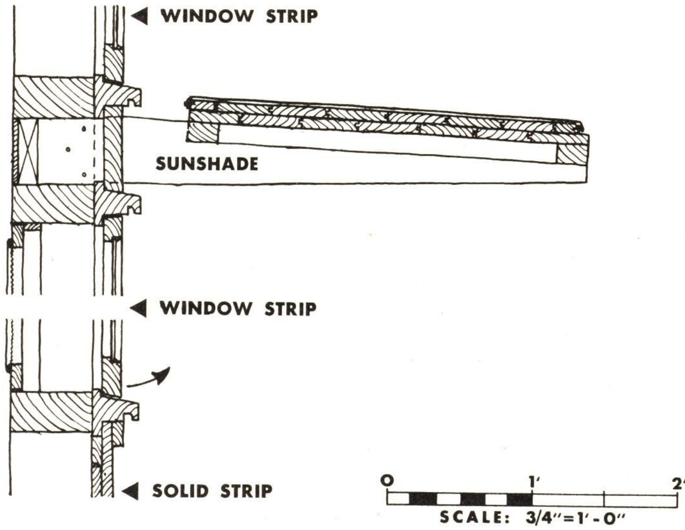
The effect of standardized elements in repetitive, textured, pattern can also be achieved on the domestic scale, particularly by use of awning windows with their many sashes and insistent horizontals. Those shown below are stock windows in extruded aluminum (see page 42 for details). Notice the sunshade formed by extension of the roof.

Architect: L. Morgan Yost (his own house). *Location:* Kenilworth, Illinois.

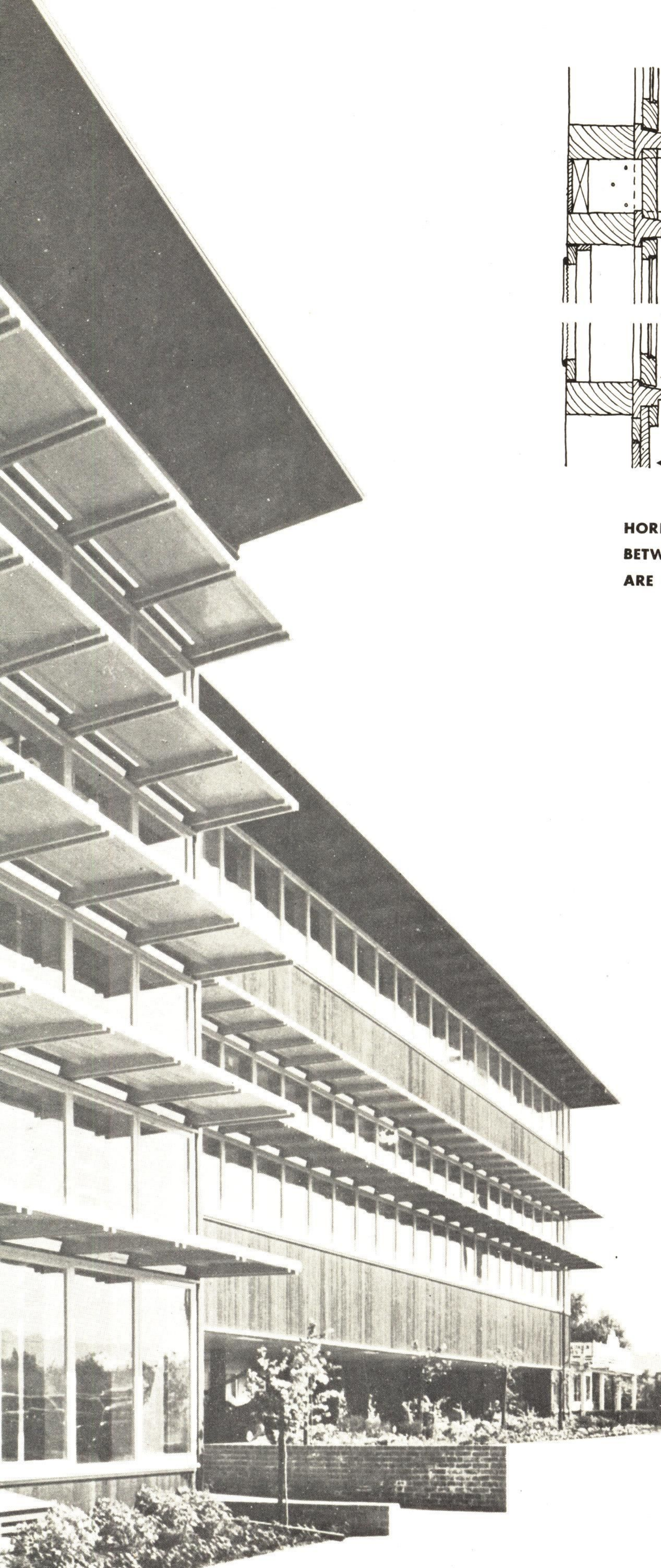


LIGHT ALUMINUM AWNING WINDOWS, ROOF SUNSHADE

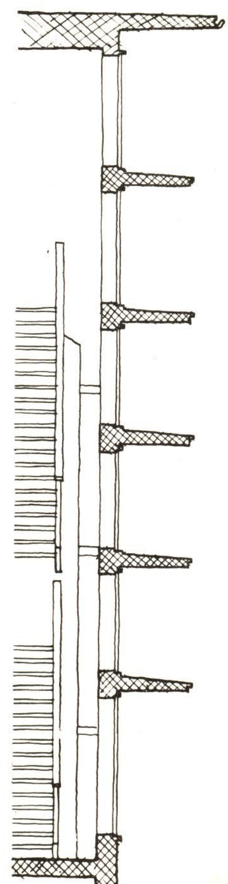




HORIZONTAL CONNECTING MEMBERS
BETWEEN SOLID AND WINDOW STRIPS AND SUNSHADES
ARE OF THE SAME SECTION UNDER ALL CONDITIONS



◀ STAIR HALL

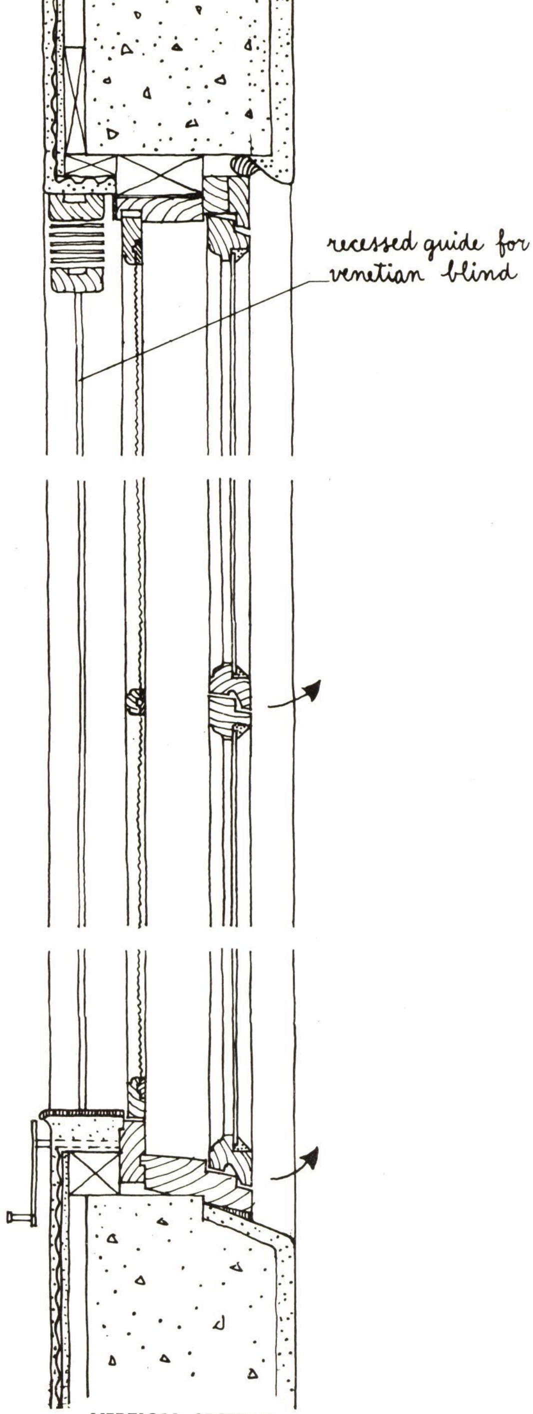


VERTICAL SECTION
THROUGH STAIR HALL WINDOW

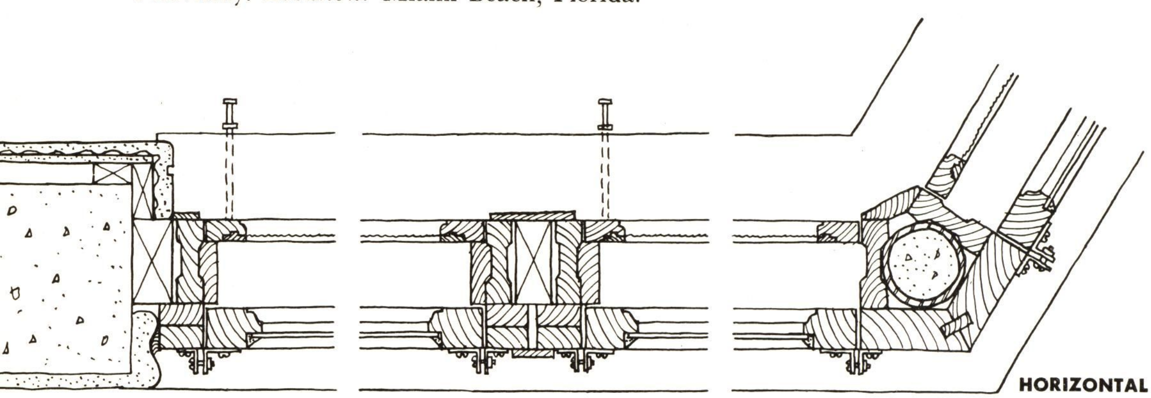
AWNING WINDOWS IN BATTERIES

Awning windows have always been most popular in the South, for they allow plenty of ventilation and can safely be left open during tropical downpours. A battery of small sash, as shown here, controlled by a single operating handle (see page 26), is more satisfactory than a few large sash. The overlapping panes prevent the rain driving in, yet allow free entry to the cooling breezes which accompany such storms. As a further step in the restless search for natural cooling, the conventional solid, flat street facade has here been broken up into a series of projecting bays and wings to catch every whiff of breeze, from whichever direction it may come. By setting the window toward the outer face of the concrete block wall, there is a deep reveal to accommodate Venetian blinds.

The Nelson Zivitz House. *Architect:* Igor B. Polevitzky. *Location:* Miami Beach, Florida.



VERTICAL SECTION



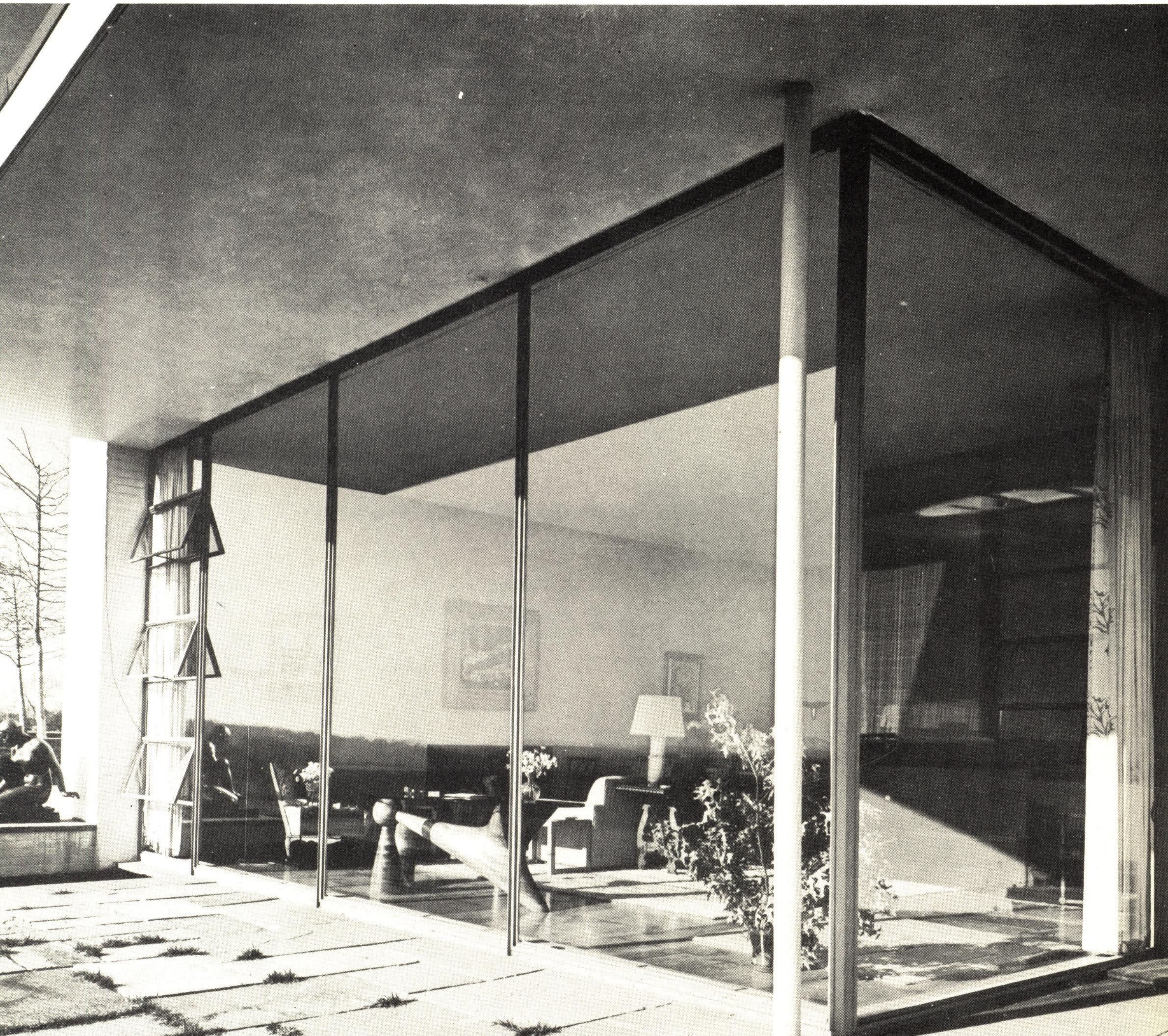
HORIZONTAL SECTION

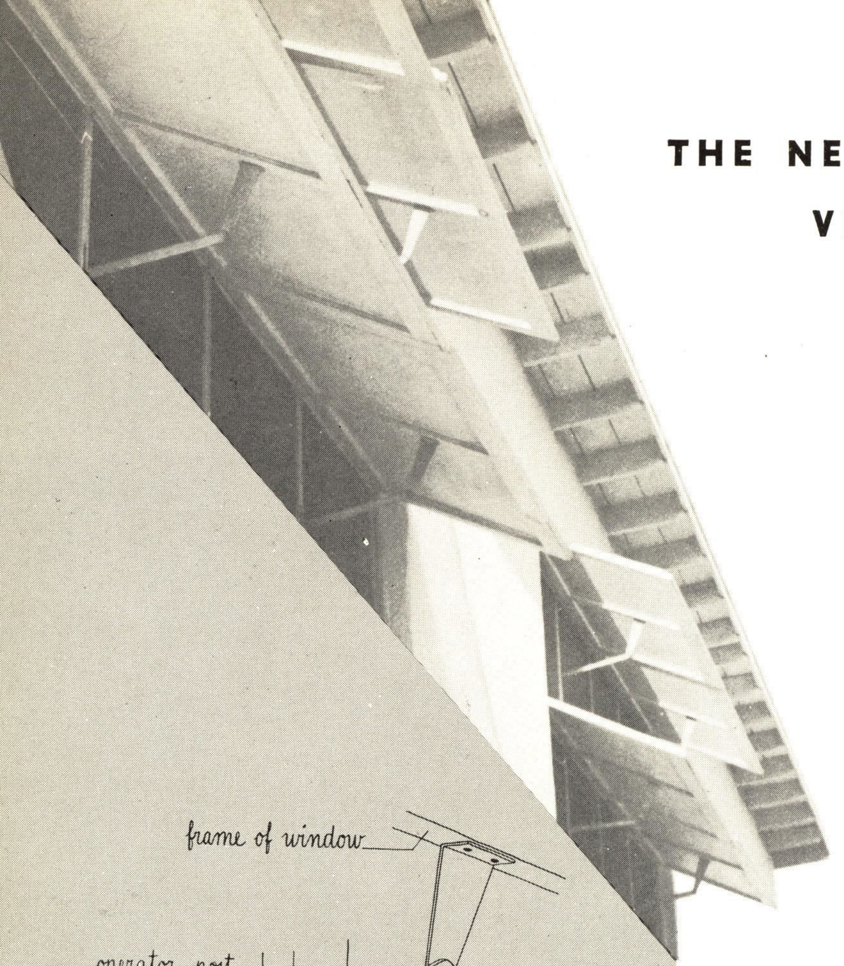
SCALE: 1½"=1'-0"

Awning windows are increasingly used as a subsidiary of large fixed glass panels, to provide weather-shielded ventilation. This transparent curtain wall, custom-made from stock sections, is a minimum interruption of the continuous (ceiling and floor) lines, which carry through from inside to out.

Architect: Edward D. Stone. *Location:* Old Westbury, Long Island, N. Y. *Owner:* Mr. A. Conger Goodyear.

FIXED SASH, AWNING VENTS

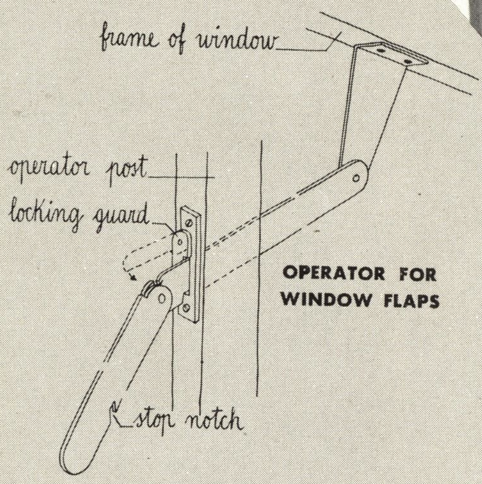




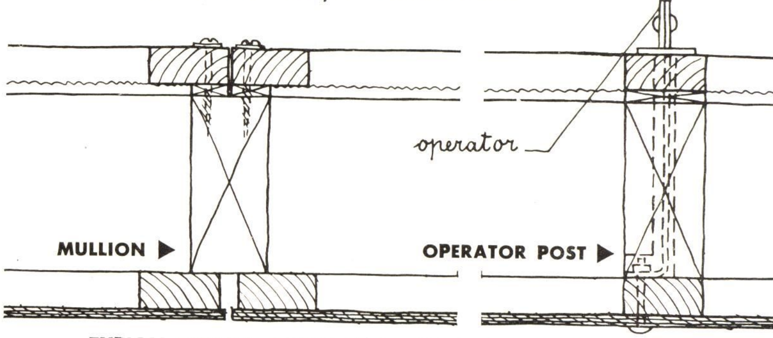
THE NEED HERE WAS LOW-COST VENTILATION, LESS LIGHT

The Farm Security Administration was faced with the need for low-cost housing for migratory agricultural workers in the South-West and California. Quite a number of row-house settlements were put up, each following the same basic designs, but each succeeding one modified and improved in detail by experience, and by the opportunities of local materials such as the adobe walls at Chandler, Arizona, illustrated opposite. To make such houses livable in a blinding heat of as much as 120 in the shade, the sleeping quarters, on the second floor, have no windows in the ordinary sense of that word, just top-hinged flaps of wood frame covered with plywood and translucent plastic. In this the designers were following local tradition of canvas-covered sunflaps to shade screened porches. Canvas, however, was not considered sufficiently durable for public housing. The operator bar was also a local type of hardware, but the locking guard, which also keeps out insects which might penetrate the slot, is an F.S.A. refinement.

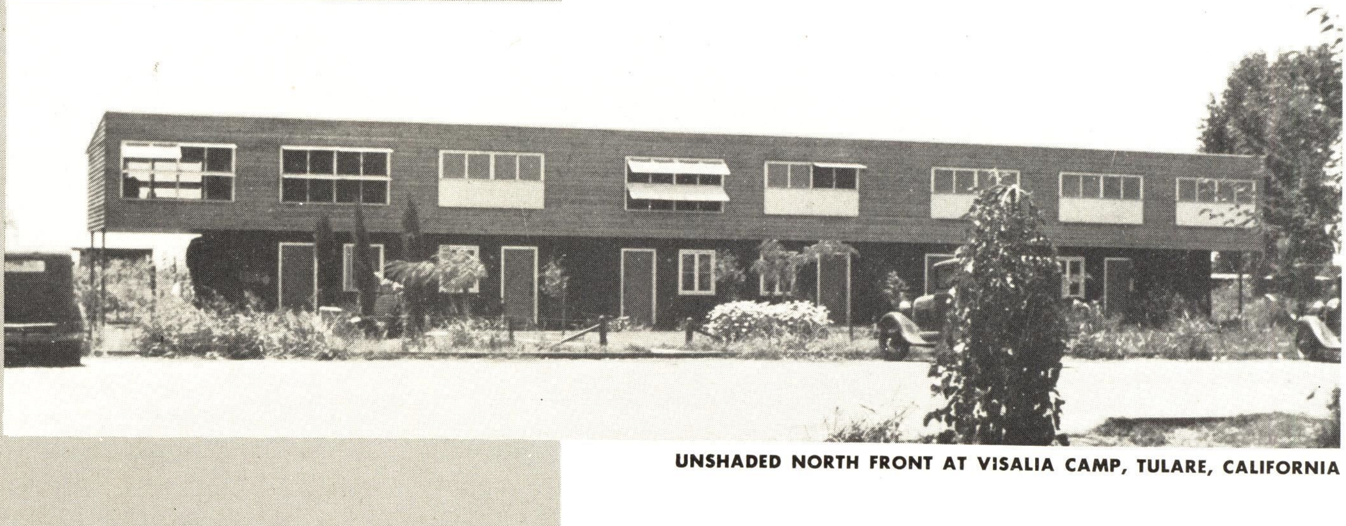
Architects: Vernon De Mars, Burton D. Cairns; for Farm Security Administration.



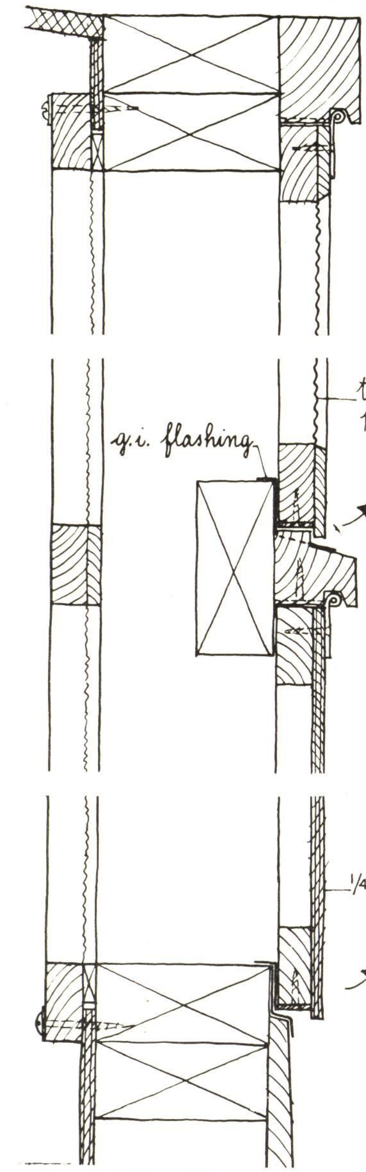
OPERATOR FOR WINDOW FLAPS



TYPICAL DETAILS: HORIZONTAL SECTION AT PLYWOOD FLAPS

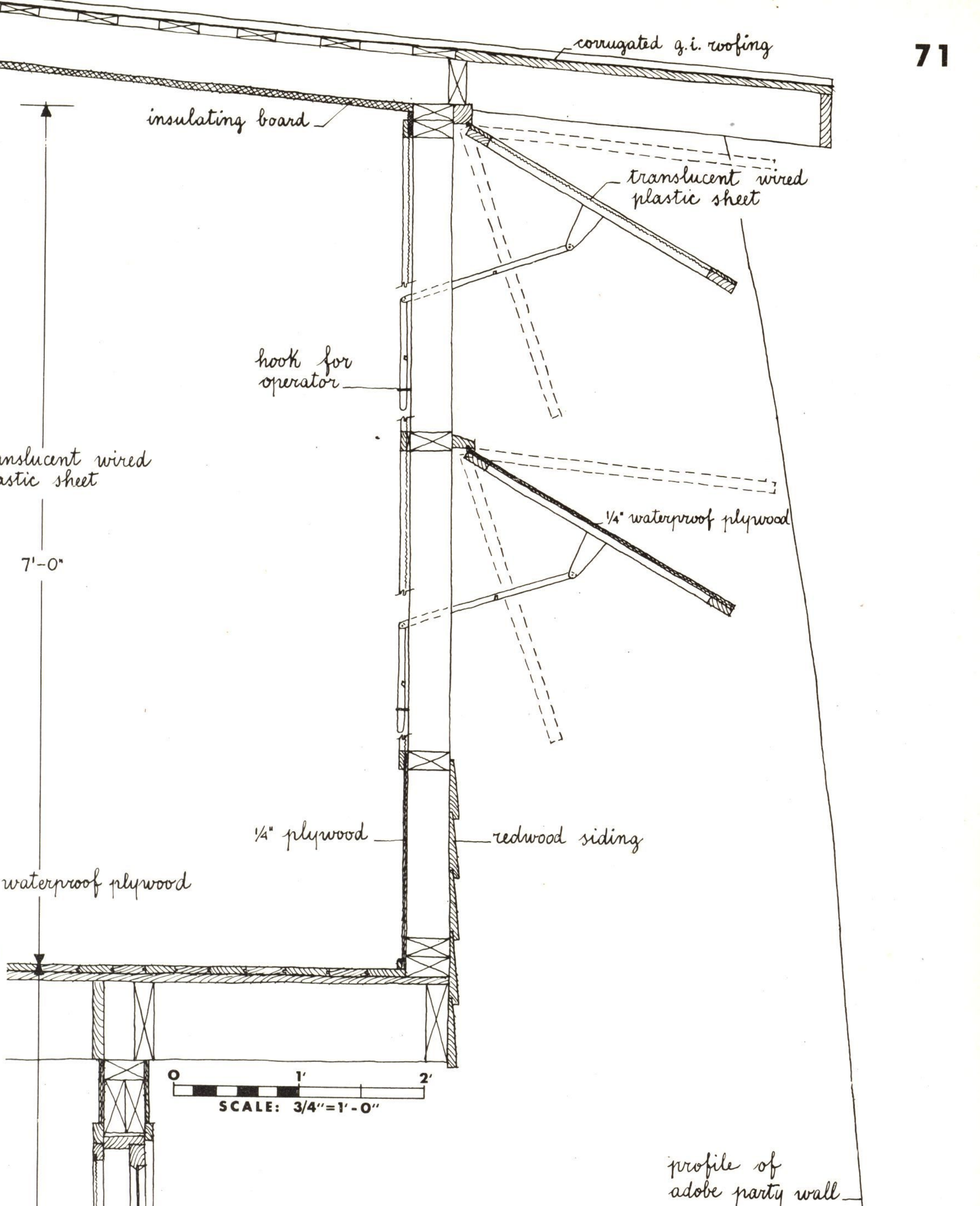


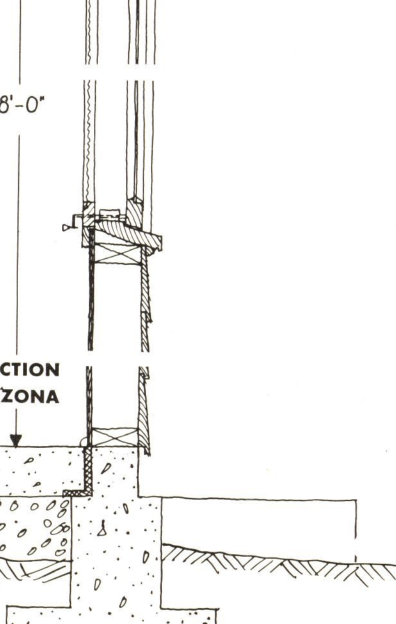
UNSHADED NORTH FRONT AT VISALIA CAMP, TULARE, CALIFORNIA



TYPICAL DETAILS
VERTICAL SECTION

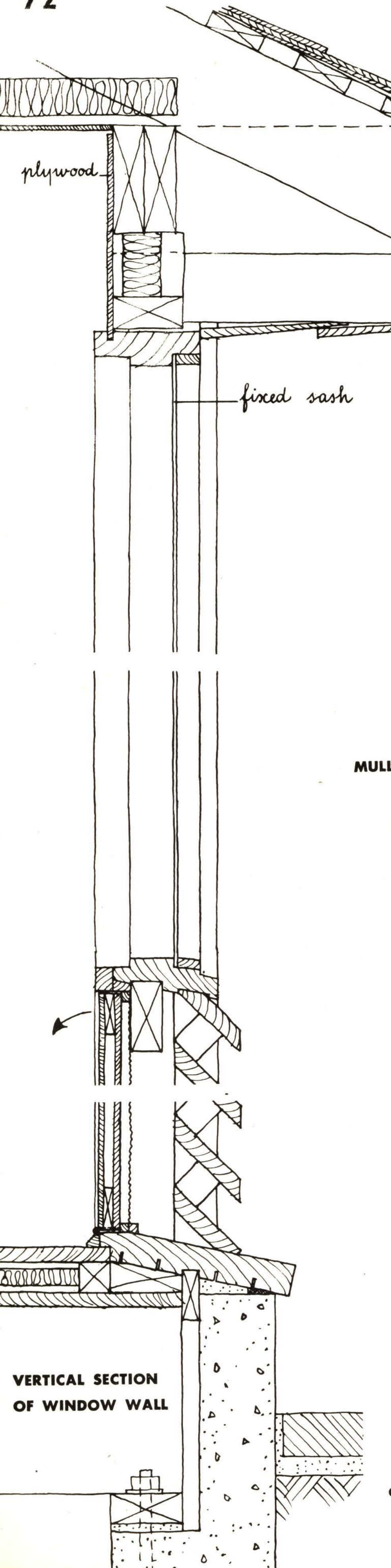
0 3" 6"
SCALE: 3"=1'-0"



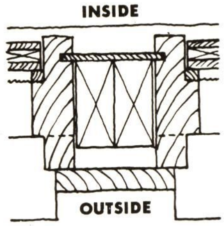


VERTICAL SECTION
THROUGH SOUTH WALL, CHANDLER, ARIZONA

ADOBE BUTTRESSES AT CHANDLER FOR SHADE, PRIVACY



VERTICAL SECTION OF WINDOW WALL



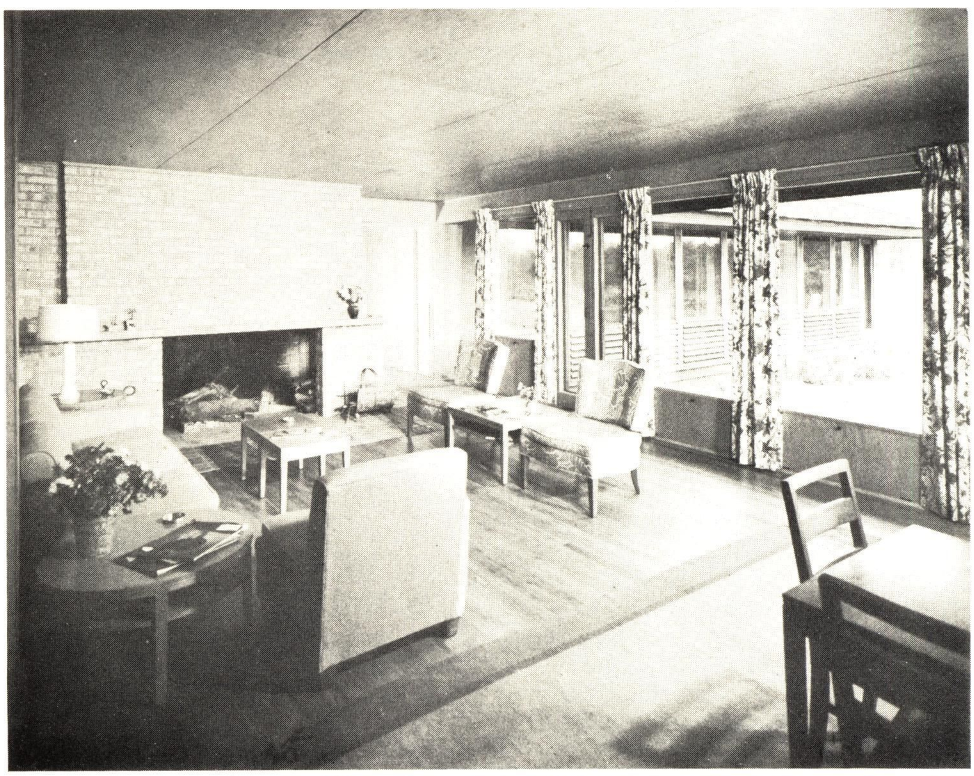
MULLION: HORIZONTAL SECTION

PROJECTING AT REAR IS THE LIVING ROOM WING WITH WINDOW WALL SHOWN IN SECTION (LEFT)

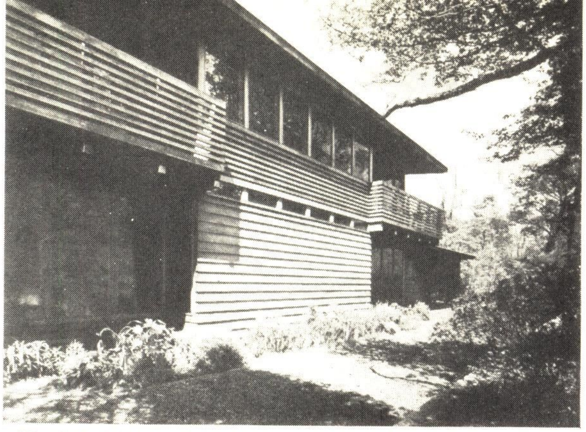
WINDOW NO LONGER USED AS VENTILATOR

Light and view in these windows come via large panels of fixed sash, uncluttered by muntins or vents, which fill the interstices between load-bearing mullion posts. Beneath the glass panels, between sill and floor, are screened openings shielded by louvers on the outside and closed on the inside by bottom-hinged panels. These control ventilation.

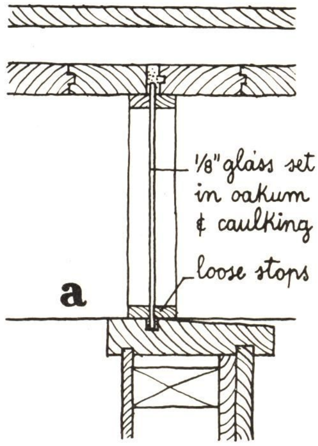
House in the Co-operative Community, Glenview, Ill. *Architects:* Schweikher & Elting.

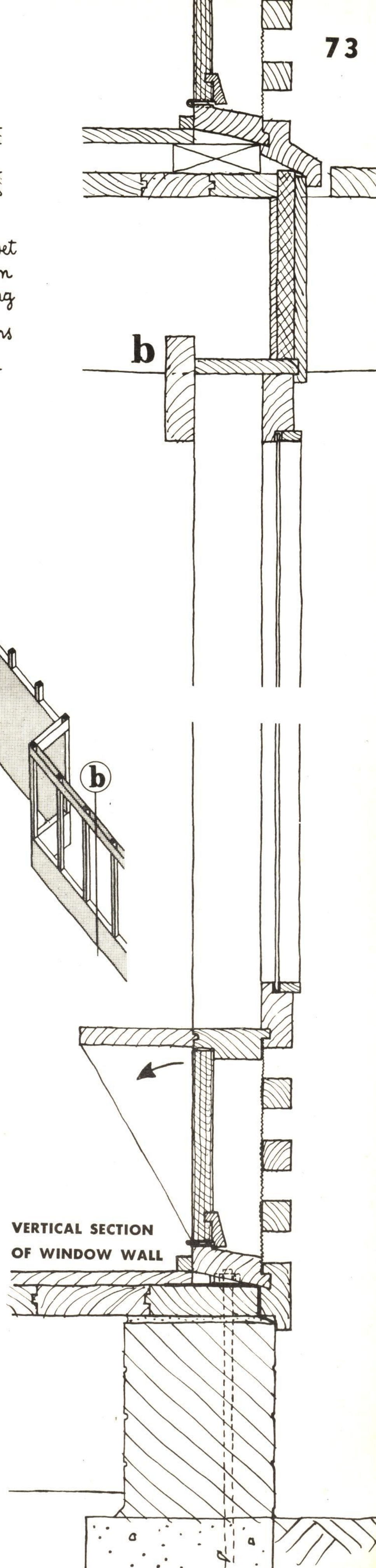


THE LIVING ROOM. BEDROOM WING SEEN THROUGH WINDOW WALL



SPACED REDWOOD BATTENS ARE VENTILATOR LOUVERS UNDER WINDOWS, BALCONY RAILS ELSEWHERE



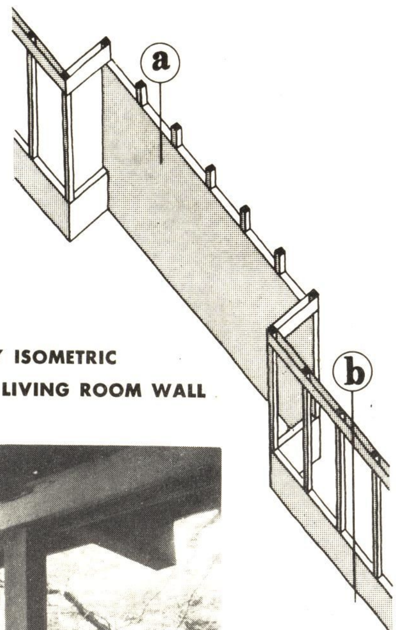


VERTICAL SECTION OF WINDOW WALL

GLASS INFILLING OF EXPOSED FRAME

As in the house shown opposite, all sash here is fixed; ventilation is by louvers. The structure of the building — framing posts and rafters set on a 3 ft. module grid—is left exposed. Where windows are needed glass is set between the posts, for ventilation louvers are added; for a solid screen (as in the bay shown) redwood siding is applied.

Architects: Schweikher & Elting. *Location:* Downers Grove, Ill. *Owner:* Mr. P. S. Rinaldo, Jr.

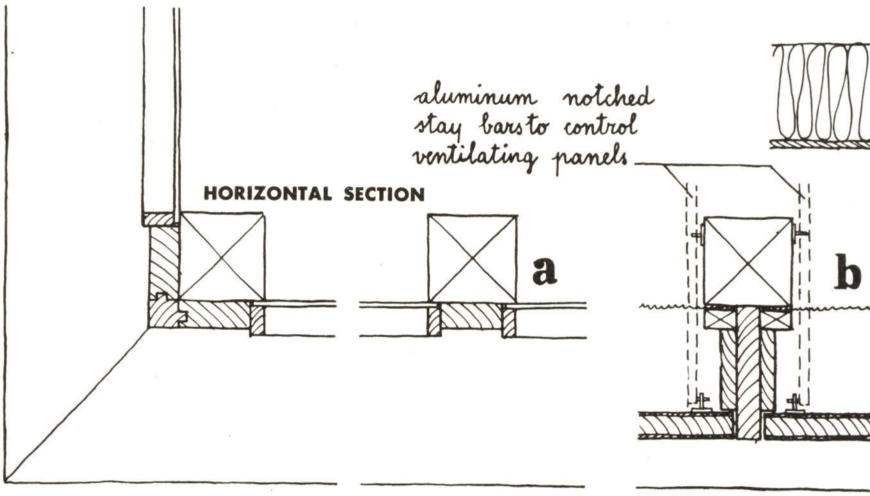


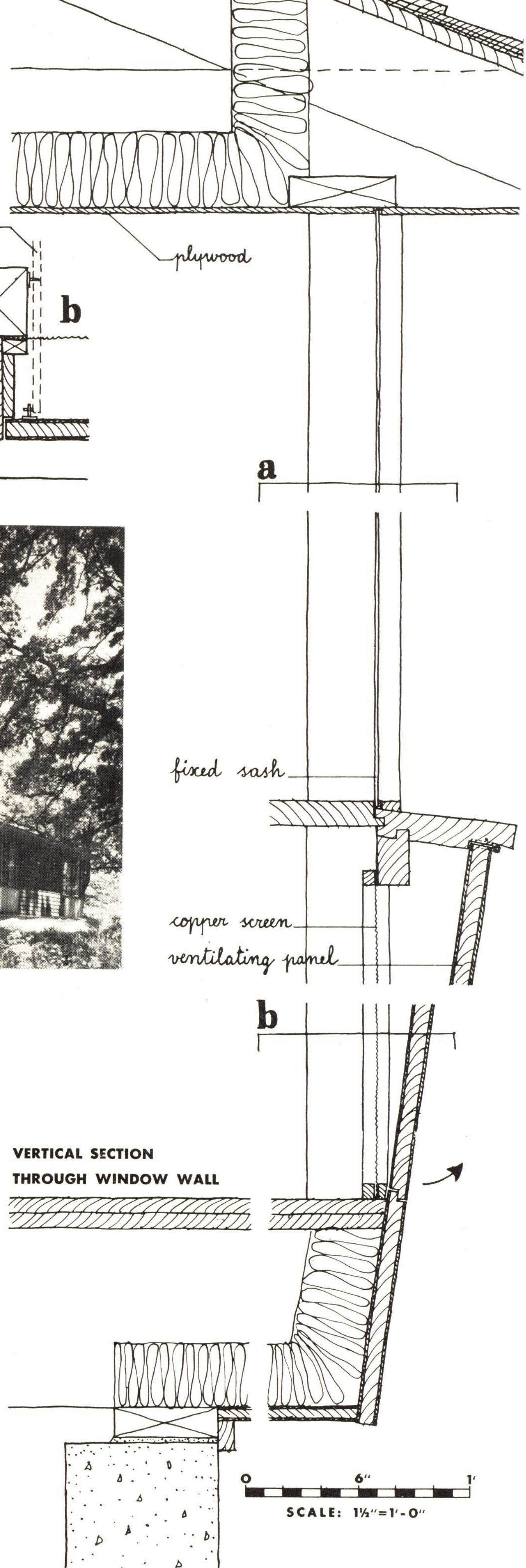
KEY ISOMETRIC OF LIVING ROOM WALL

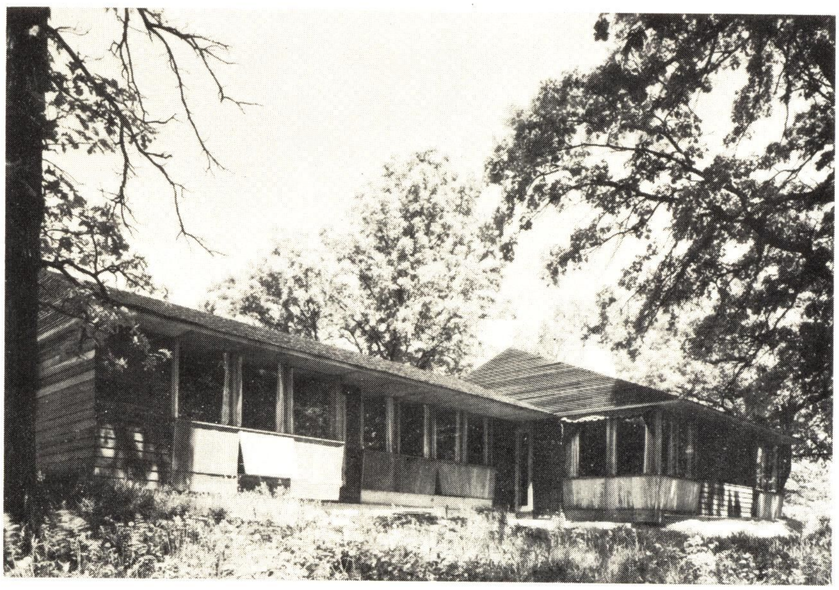
THE SOLID BAY IN THIS WINDOW WALL IS OPPOSITE THE FIREPLACE

0 6" 1'

SCALE: 1½"=1'-0"



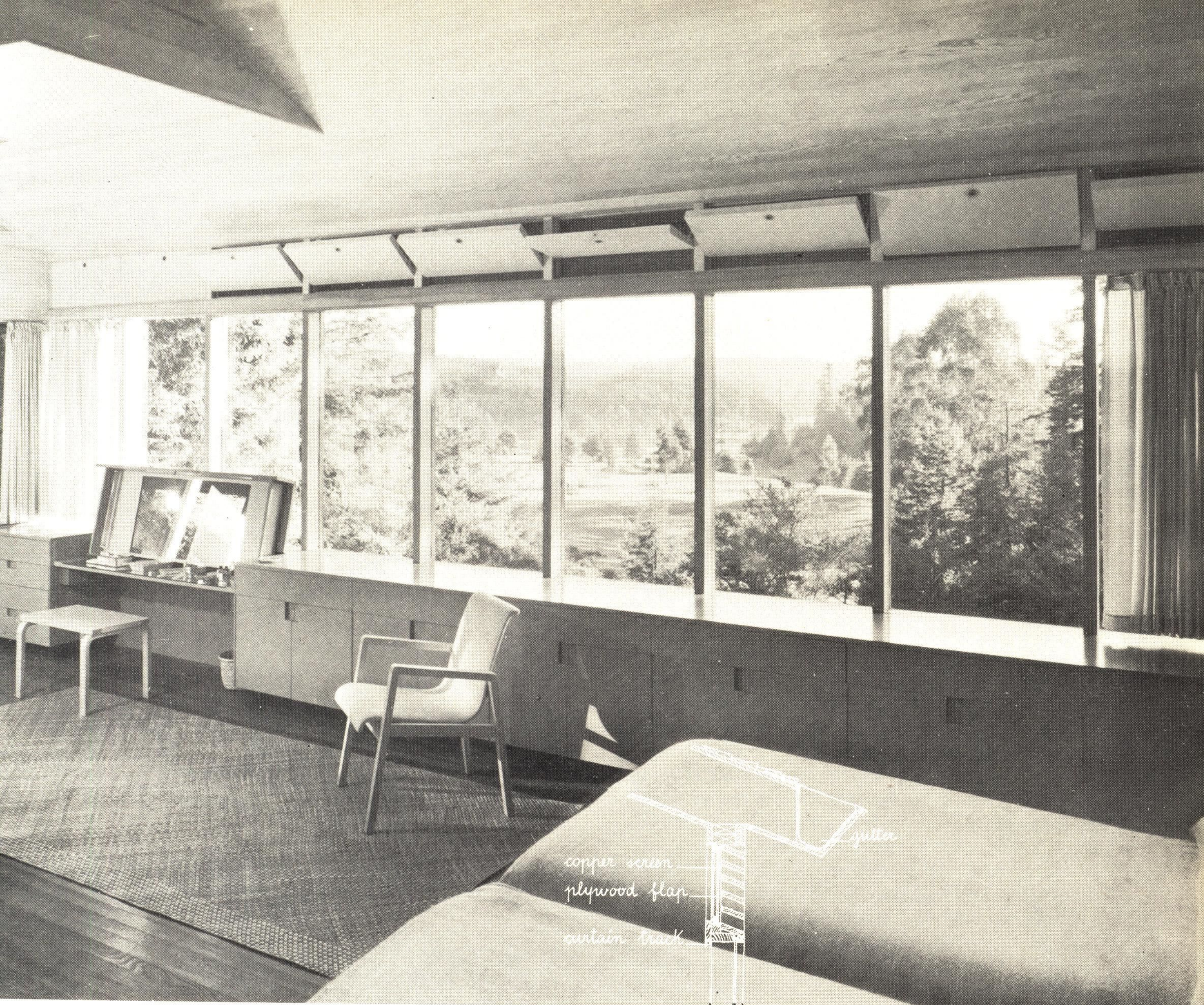




VENTILATING DOORS INSTEAD OF LOUVERS

This is a simplified and more economical version of the fixed sash and louver combinations shown on the last two pages. Here, instead of ventilating doors *and* louvers, only the doors are necessary; and being on the outside they do not protrude within the room. On the other hand the screen is always visible on the interior face of the wall. Skilfully used, these flaps can give an interesting texture to the outside face of the wall, like awning windows.

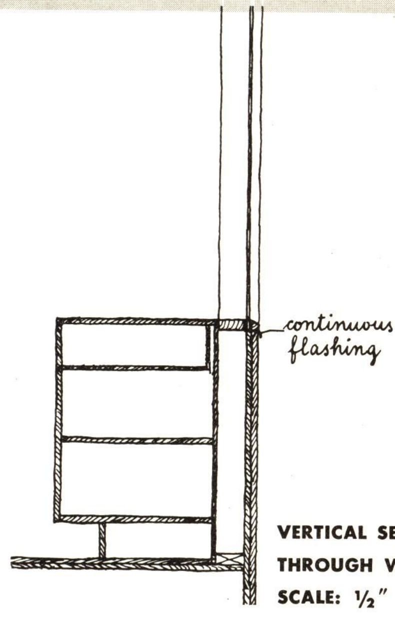
Architects: Schweikher & Elting. *Location:* McHenry Co., Illinois. *Owner:* Mr. Harry W. Goebel.



VENTILATORS SET ABOVE WINDOW STRIP

At present there is diversity of opinion regarding the best position for ventilation openings used with fixed sash. Placed above the window strip, these are out of the way and protected by the roof overhang. On the other hand they are more difficult to reach and may be slightly less efficient as ventilators. But they do leave the space below the windows free for a row of built-in cabinets, including a dressing table with swing-up mirror top, and built-in fluorescent lighting.

House in North California. *Architect:* John Yeon.

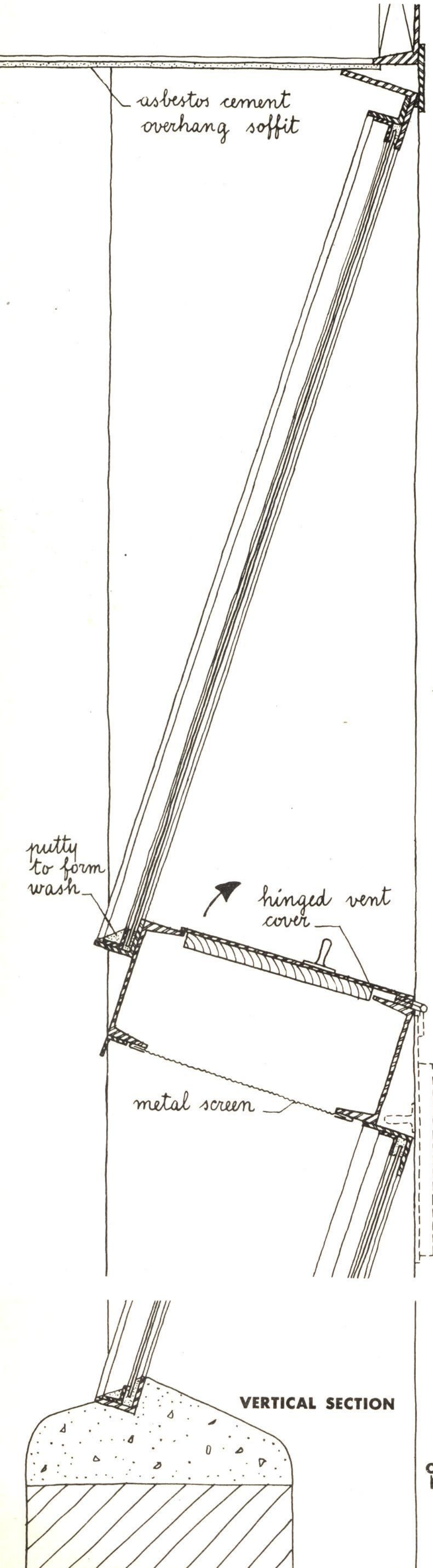


VERTICAL SECTION THROUGH WINDOW WALL
SCALE: ½″ = 1′ - 0″

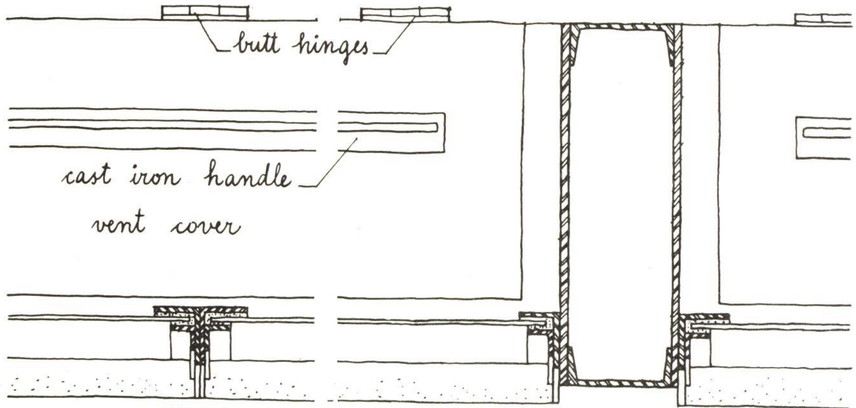
FLAP VENTILATORS IN DEPTH

Fixed sash and flap ventilators, which scarcely hinder vision even when open, display this diesel generating plant to passers-by on an adjoining highway and railroad. Fitted within the depth of the structural steel frame, the ventilators can be left open during any weather, and are also well placed to prevent condensation. The original design was largely dictated by wartime shortage of metal sash. Now the architects say that the only change they would make is to use a lighter material, probably aluminum, for the ventilating flaps.

Architects: Long & Thorshov Inc., Robert G. Cerny, consultant. *Location:* Cambridge, Minn.



VERTICAL SECTION

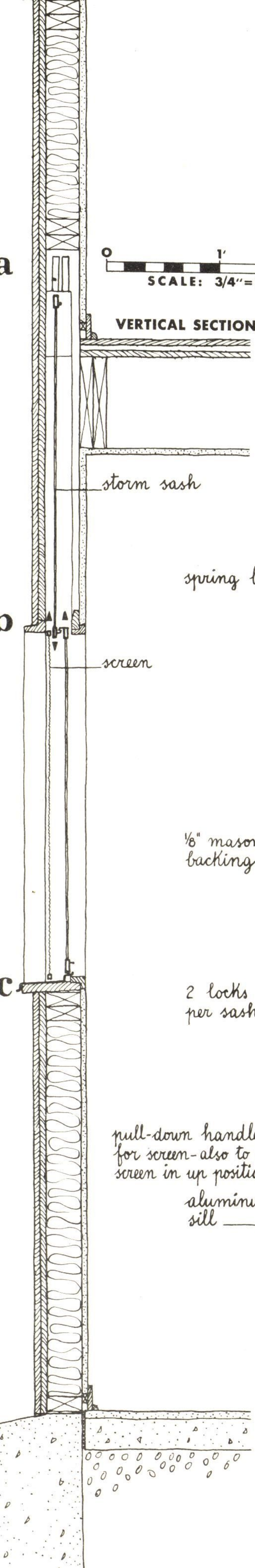


MUNTIN

MULLION

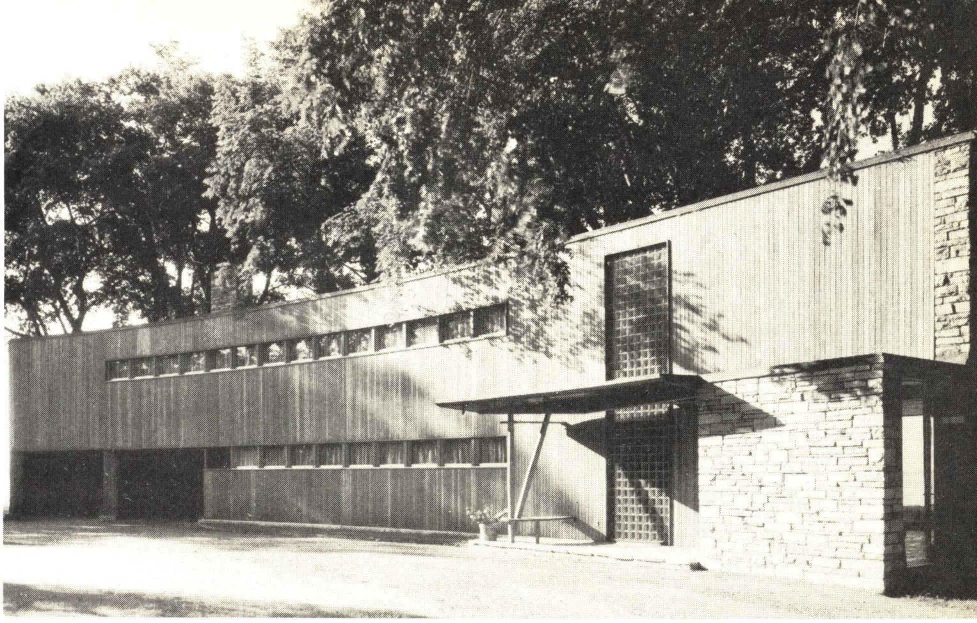
0 6" 1'

SCALE: 1½"=1'-0"



SCALE: 3/4"=1'-0"

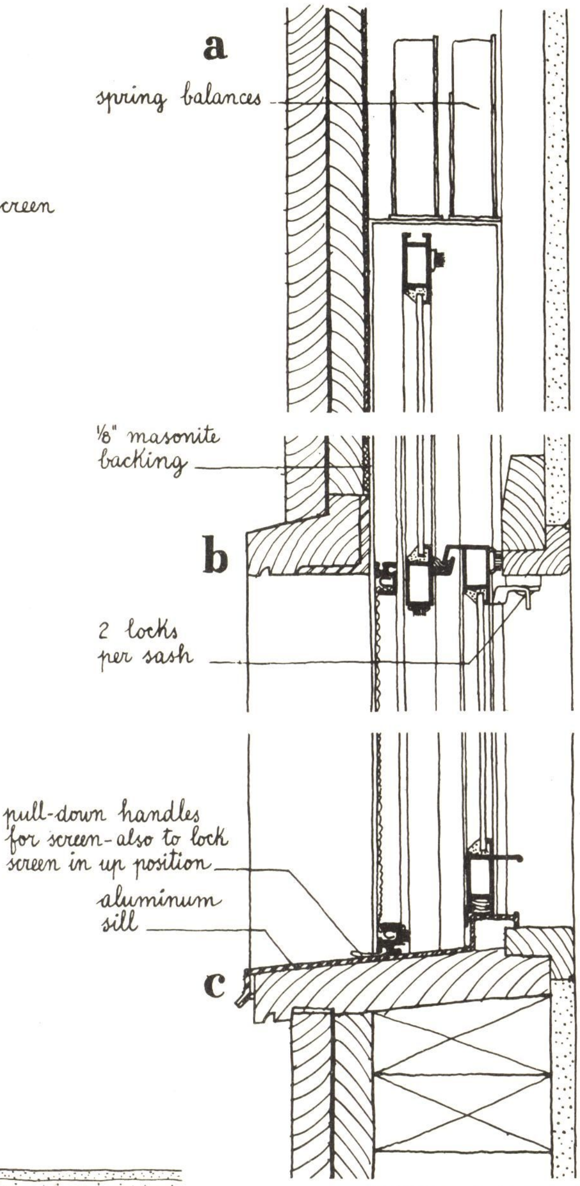
VERTICAL SECTION THROUGH ENTRANCE FRONT



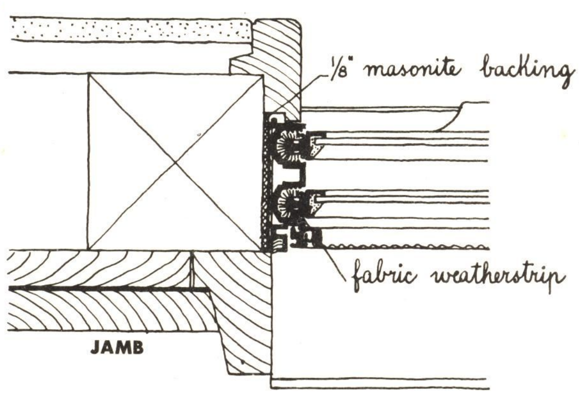
YEAR-ROUND WINDOW SLIDING INTO WALL

Stock aluminum double-hung windows are here set with their upper halves buried within the wall above the window opening. The upper sash now acts as a storm window which is lowered in winter, raised to what would normally be its closed position during the summer. A half screen can be lowered to cover the window opening when needed, slid up within the wall the rest of the time. The only change necessary to make this stock window perform in such a custom-made fashion is two extra pieces of weather-stripping. This arrangement would be scarcely feasible with wood sash (too thick to accommodate within the standard stud wall), nor where large window openings were wanted (insufficient wall space for sash storage, standard sash not sufficiently large). Here, on the entrance front, comparatively small windows work well. On the other side of the house, which faces south, large fixed sash open on to the lake view.

Architects: George Fred & William Keck. *Location:* Menasha, Wis. *Owner:* Mr. William Kellett.



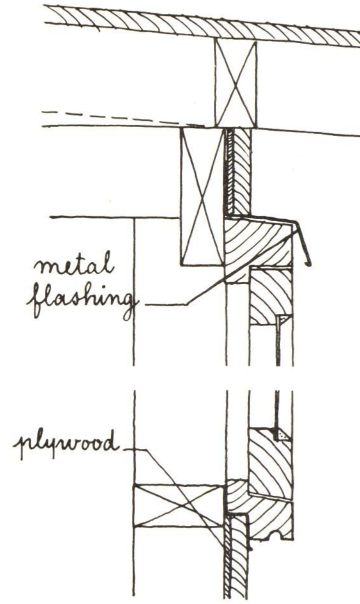
VERTICAL SECTION



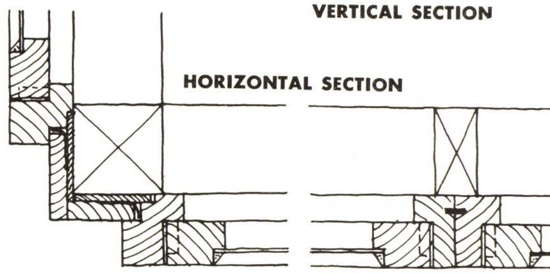
JAMB

0 3" 6"

SCALE: 3"=1'-0"



VERTICAL SECTION



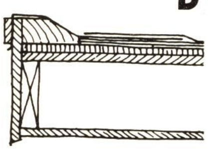
HORIZONTAL SECTION

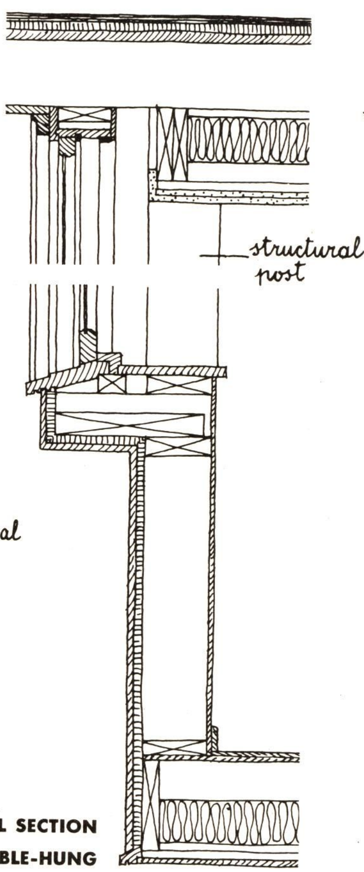
FRAMING AND WINDOWS ON SAME MODULE

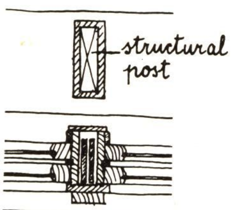
0 6" 1'

SCALE: 1½"=1'-0"

DOUBLE-HUNG PROJECTED BEYOND FRAMING

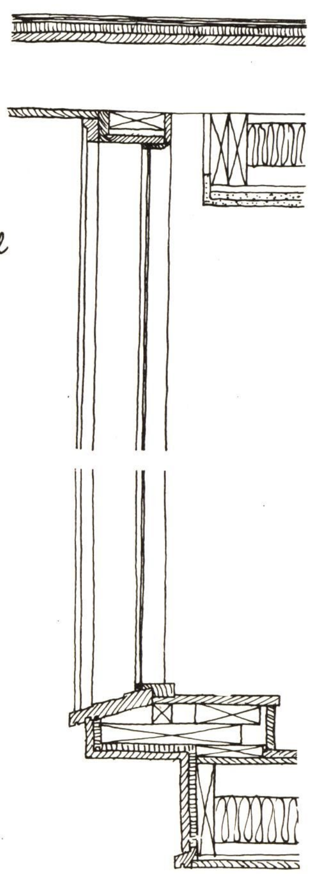






MULLION
BETWEEN DOUBLE-HUNG

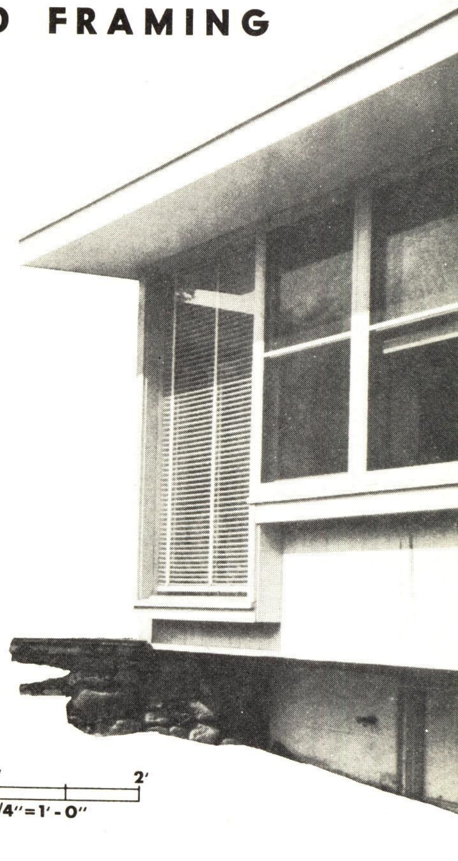
VERTICAL SECTION
THROUGH DOUBLE-HUNG

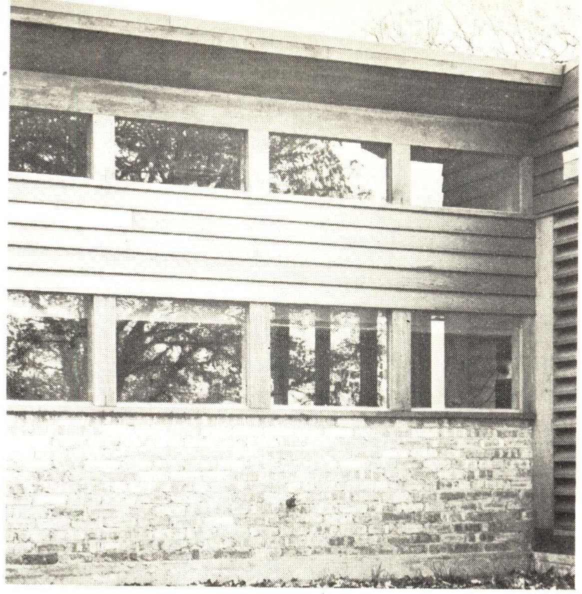


0 1' 2'

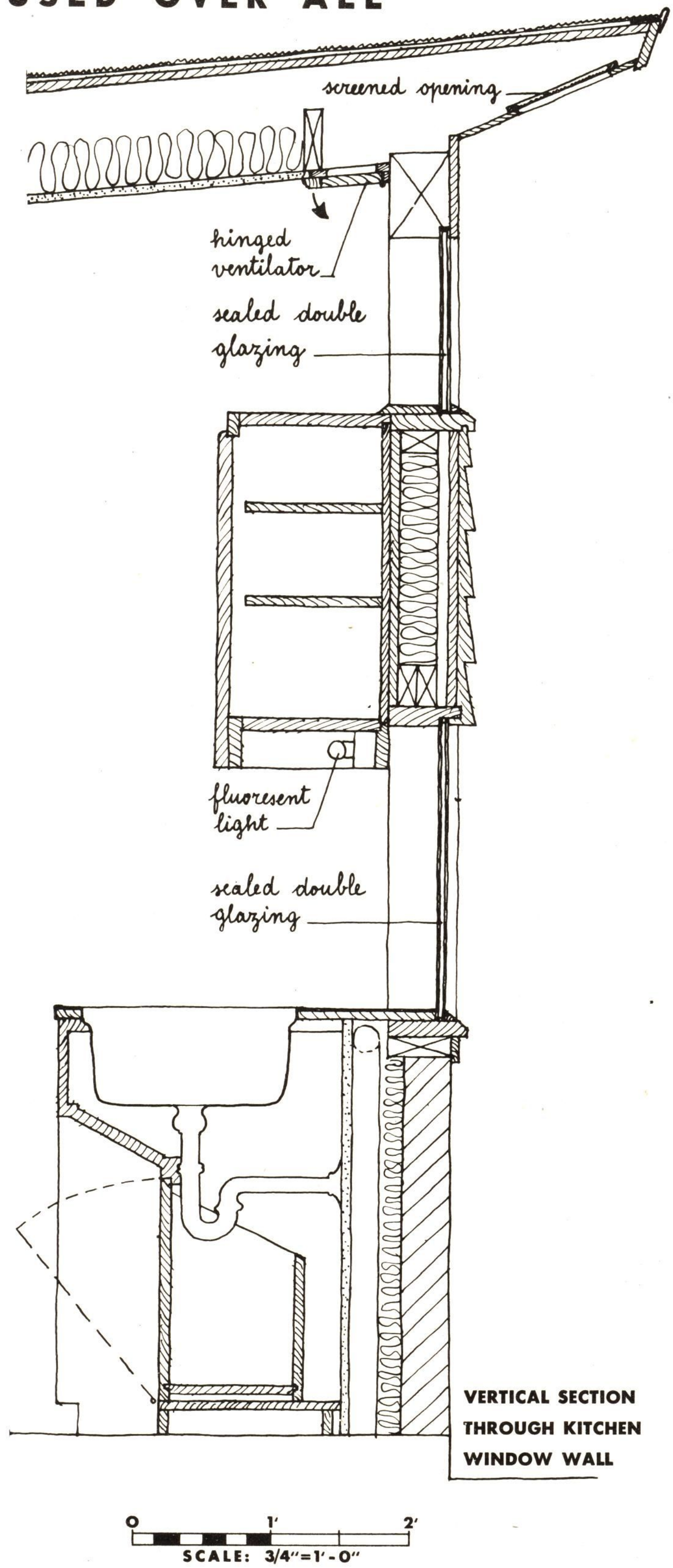
SCALE: 3/4"=1'-0"

VERTICAL SECTION
THROUGH FIXED SASH





DIVIDED KITCHEN WINDOW: DIRECT LIGHT AT COUNTER, DIFFUSED OVER ALL



VERTICAL SECTION THROUGH KITCHEN WINDOW WALL

above and right:

This is a logical development of the kitchen window wall. It is continuous along one side of the room. Overall diffused lighting is by the clearstory strip. The solid section allows for wall cabinets which project to shield the worker from looking directly into the light which floods the work surfaces. For night lighting there are fluorescent lamps recessed in the cabinet bases. The sealed double glazing in both window strips is fixed. Ventilation is by adjustable openings in the ceiling above the windows.

Architect: L. Morgan Yost. *Location:* Highland Park, Illinois. *Owners:* Mr. and Mrs. N. C. Deno.

opposite page top:

Too often the wooden house frame is hacked about and cut away to accommodate the windows. Here stud spacing and window width is correlated, the windows being fixed to the outside face of the studs (cf. page 81). The latter are left exposed on the interior face of the wall, a decorative pattern born directly of structural requirements.

Architects: Wurster, Bernardi & Emmons. *Location:* Tiburon, Cal. *Owners:* Mr. and Mrs. O. Lyman.

opposite page bottom:

By projecting these stock wood double-hung windows beyond the face of the building frame, the window head can be brought up to the underside of the lookouts (2 x 6), which are only half the depth of the main rafters (2 x 12). The window head is thus carried above the ceiling level, allowing a clear sight line through from the ceiling out, and also creating a useful pocket for blinds. Mullions, now separate from structural posts, can be much thinner. All these are worthwhile advantages, though gained only at the expense of some framing complications.

Architects: Sanders & Malsin. *Location:* Croton-on-Hudson. *Owner:* Mrs. Lane Malsin.

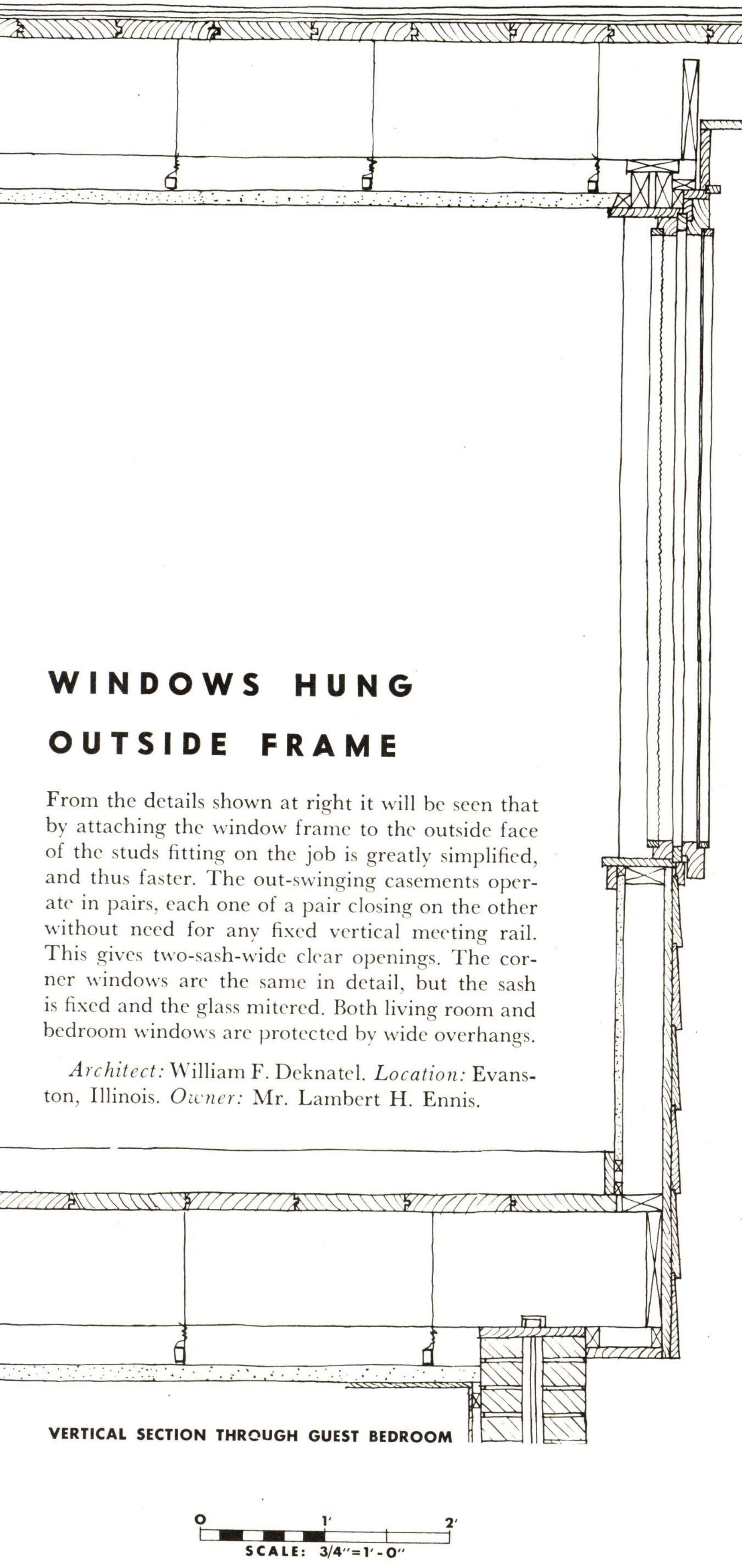
◀ GUEST BEDROOM

◀ LIVING ROOM

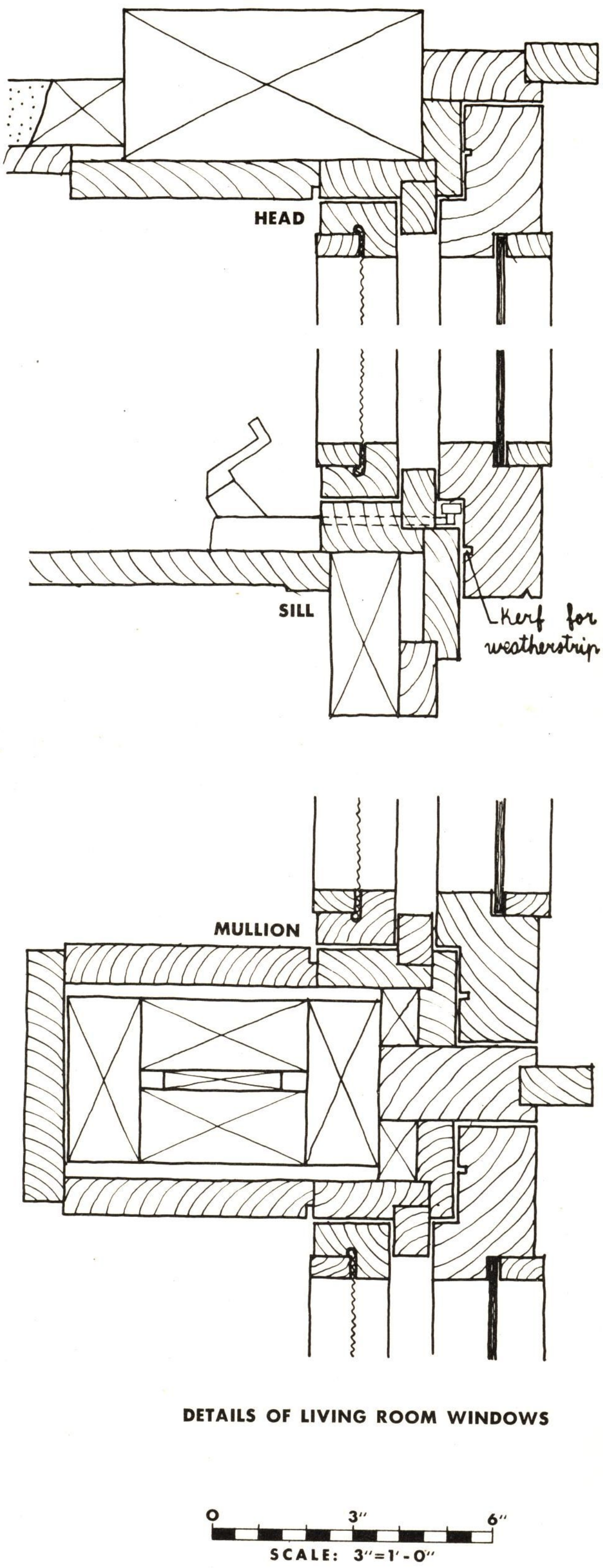
WINDOWS HUNG OUTSIDE FRAME

From the details shown at right it will be seen that by attaching the window frame to the outside face of the studs fitting on the job is greatly simplified, and thus faster. The out-swinging casements operate in pairs, each one of a pair closing on the other without need for any fixed vertical meeting rail. This gives two-sash-wide clear openings. The corner windows are the same in detail, but the sash is fixed and the glass mitered. Both living room and bedroom windows are protected by wide overhangs.

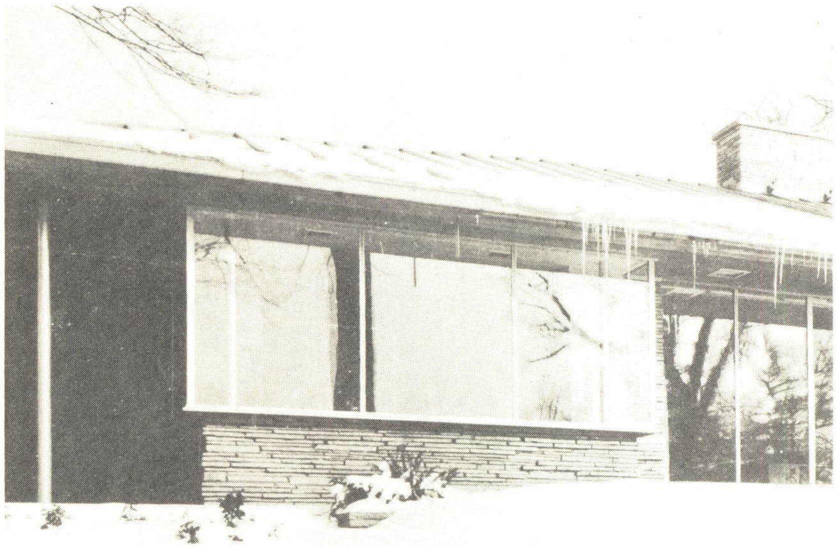
Architect: William F. Deknatel. *Location:* Evanston, Illinois. *Owner:* Mr. Lambert H. Ennis.



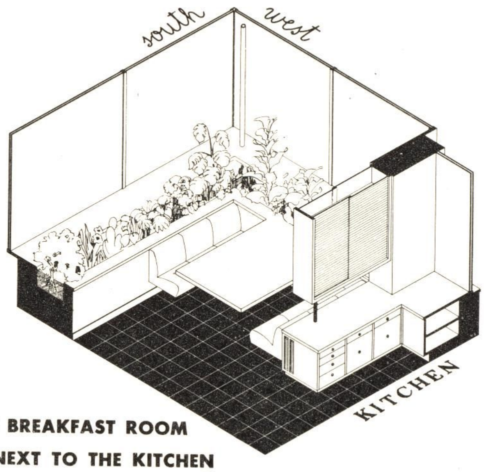
VERTICAL SECTION THROUGH GUEST BEDROOM



DETAILS OF LIVING ROOM WINDOWS



SOUTH WALL WITH PROJECTING PLANT WINDOW

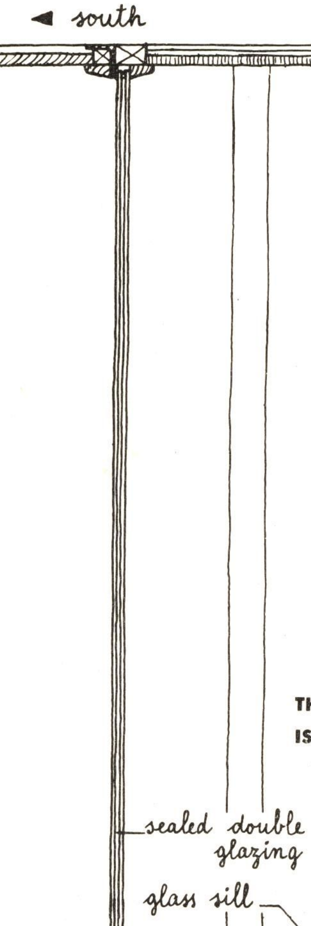


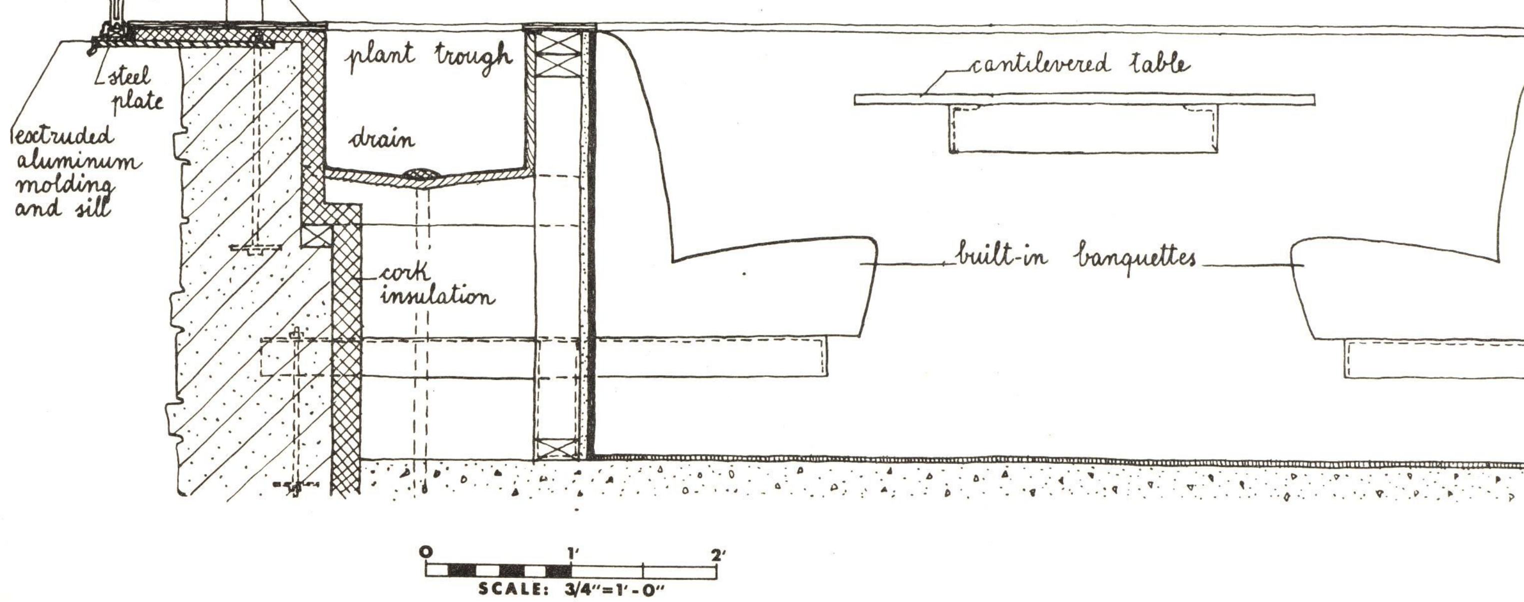
THE BREAKFAST ROOM IS NEXT TO THE KITCHEN

SEALED FOR AIR CONDITIONING

All the windows in this completely air-conditioned house are fixed sash with sealed double glazing in extruded aluminum moldings. Here, on the southwest corner of the house, the sash is projected beyond the frame of the building to give a wider sill for the plant trough. Not only are the plants advantageously oriented, but they also provide charming decoration for the little breakfast room.

Architect: Gordon S. Adamson. *Location:* Toronto, Ontario, Canada.

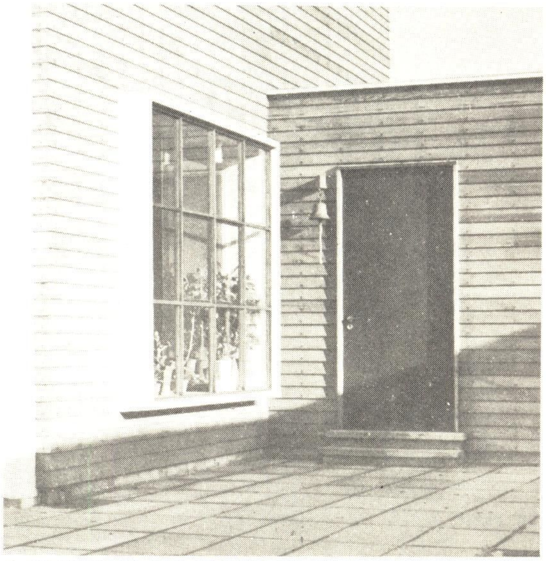




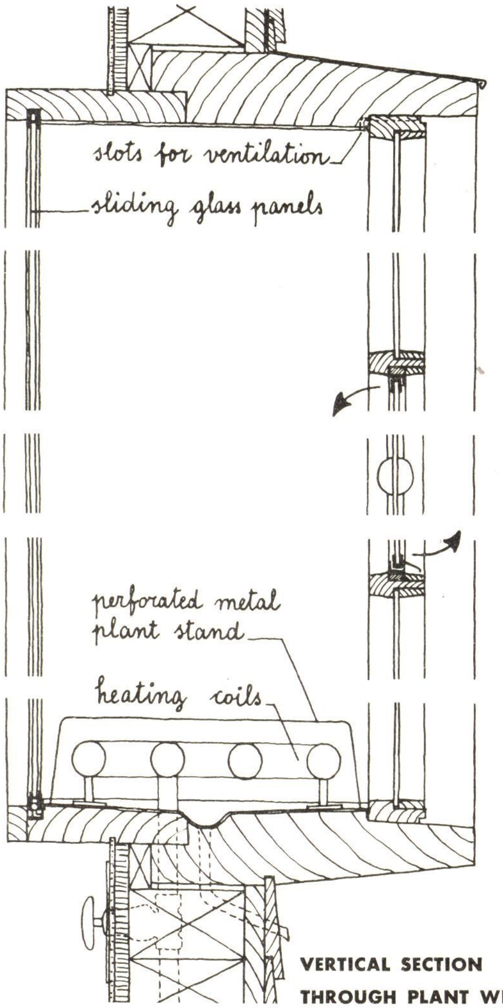
SHOWCASE WINDOW FOR PLANT DISPLAY

To accommodate the width of the shelf and give the plants ample light, this window has been boxed out from the face of the wall like a showcase. It can be isolated from the interior of the house by sliding glass panels, and the temperature within this space can be quite exactly controlled by regulating the heating coil below the perforated plant shelf.

Architect: Serge Chermayeff (his own house). *Location:* Halland, Sussex, England.



A SHOWCASE FOR PLANTS BY THE FRONT ENTRANCE



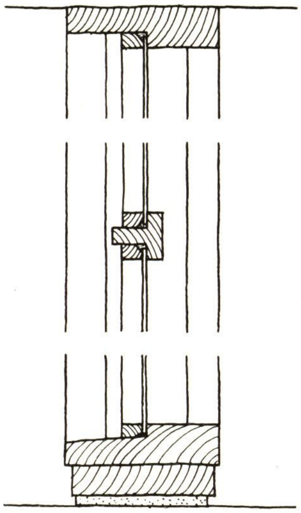
VERTICAL SECTION THROUGH PLANT WINDOW

SCALE: 1½"=1'-0"

SLOPING WINDOW WITH PLANT TROUGH

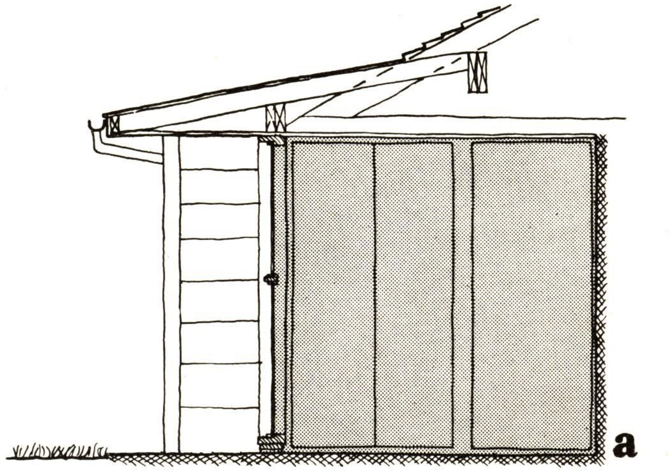
To gain a miniature greenhouse without loss of floor space, this large fixed sash has been sloped outward to accommodate a plant trough. The plants being projected further into the outdoors thus receive more light. Moreover the visibility, from indoors, through this sloping window may be improved, due to elimination of certain glass reflections. The sash itself is notable for the clean elegance of its design, largely due to delicate muntins widely spaced.

Designer: Paul László. *Location:* Bel Air, California. *Owners:* Mr. & Mrs. Phillips.



DETAILS OF FIXED GLASS FRONT

SCALE: 1½"=1'-0"

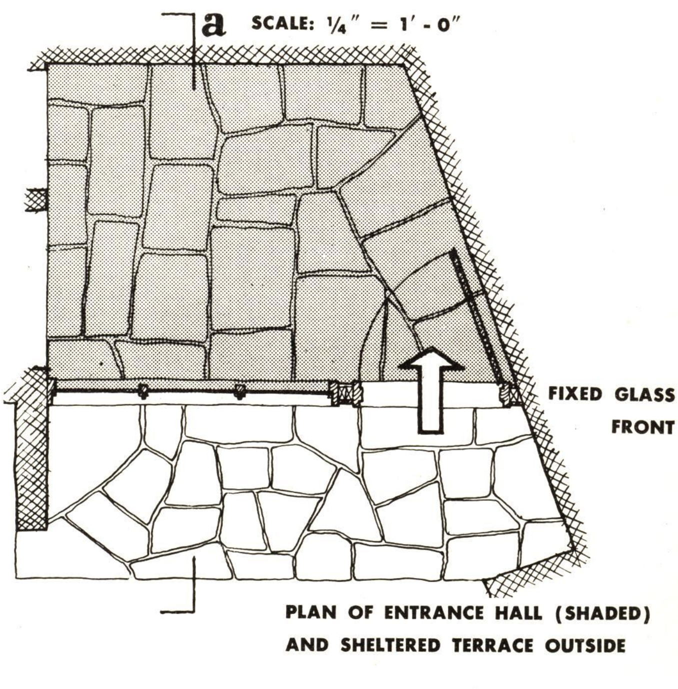


FIXED GLASS FRONT   VERTICAL SECTION

GLASS-FRONTED ENTRANCE HALL

When only a limited area can be set aside for an entrance hall, it is obviously most important to make that area appear as spacious and well-lighted as a glass wall will allow. In this example beauty lies in the general proportions rather than in the details, which are simple, conventional.

The Carrera House. *Architect:* Antonin Raymond. *Location:* Montauk, Long Island, N. Y.



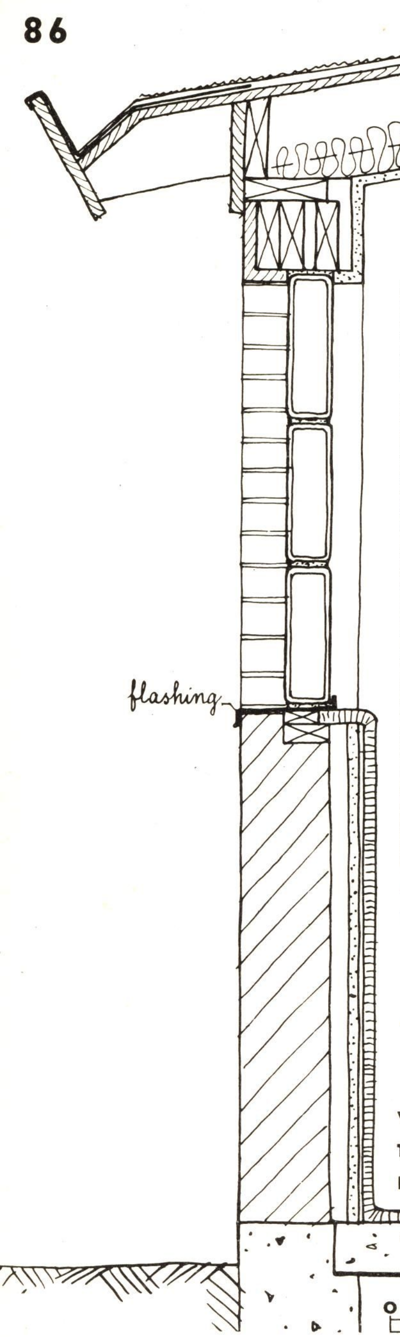
PLAN OF ENTRANCE HALL (SHADED) AND SHELTERED TERRACE OUTSIDE

GLASS BLOCKS FOR LIGHT WITHOUT SIGHT

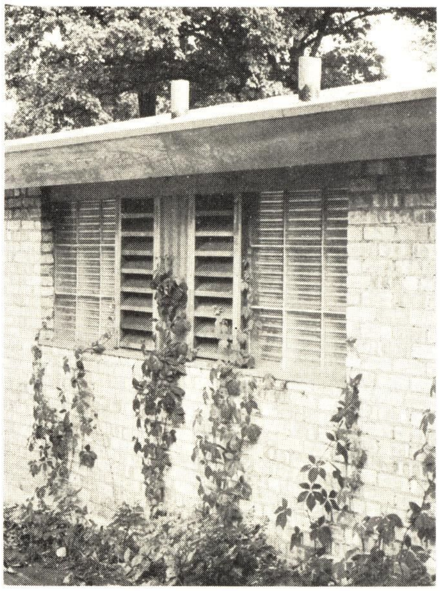
Apart from interior partitions, the most useful possibility for the use of glass block in a private home is for the exterior walls of bathrooms and entrance halls. In both cases it is usually considered desirable, at least in built-up neighborhoods, not to allow clear through vision. In such cases glass block has the advantage of better sound insulation than any translucent sheet glass, even when the latter is used in sealed double glazing. For lighting an entrance hall glass blocks have the additional merit of greater security. If ventilation is needed as well as light, then louvered, screened openings, closed by solid doors on the inside, as used in the bathroom shown at left, are a most logical device.

LEFT. *Architect:* Morgan L. Yost. *Location:* Highland Park, Illinois. *Owners:* Mr. and Mrs. Norman C. Deno.

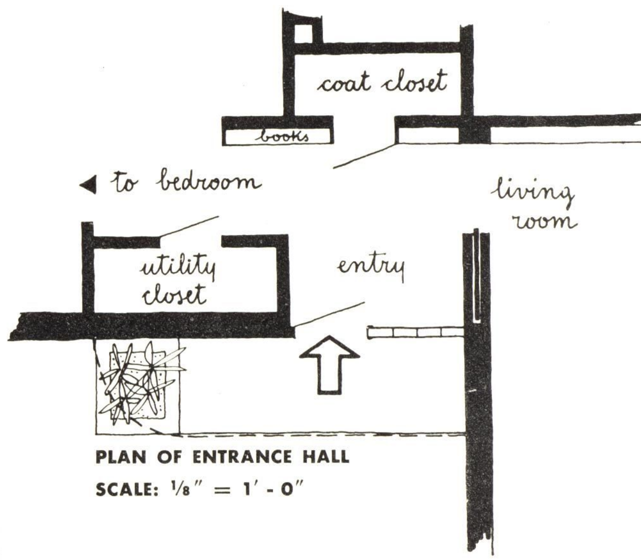
BELOW. *Architect:* Richard A. Morse. *Location:* Tucson, Arizona. *Owner:* Mr. Mathew W. Flinders.



VERTICAL SECTION THROUGH GLASS BLOCK PANEL IN BATHROOM WALL

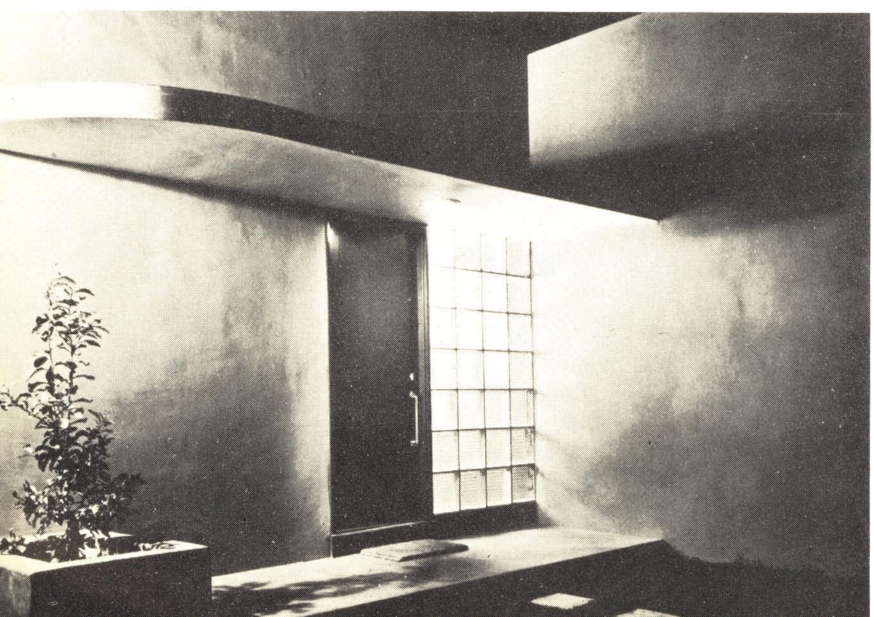


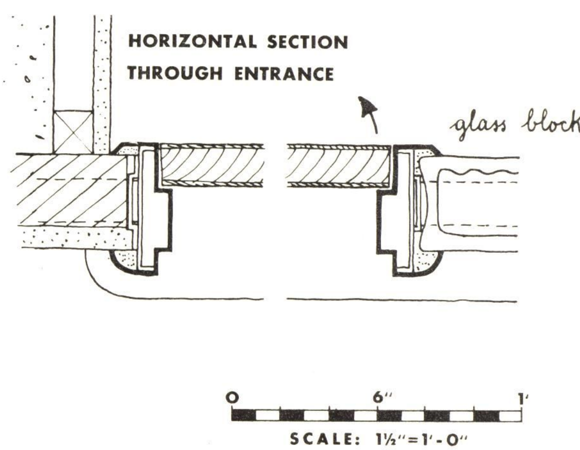
ALTERNATE PANELS OF GLASS BLOCK AND WOOD LOUVERS FOR LIGHT, VENTILATION



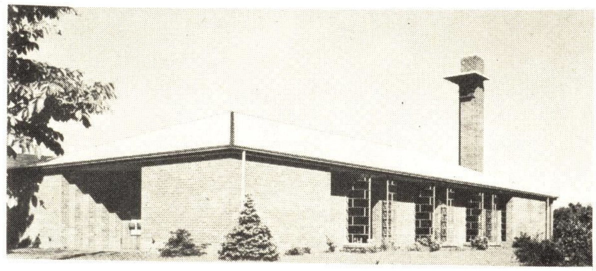
PLAN OF ENTRANCE HALL

SCALE: 1/8" = 1' - 0"





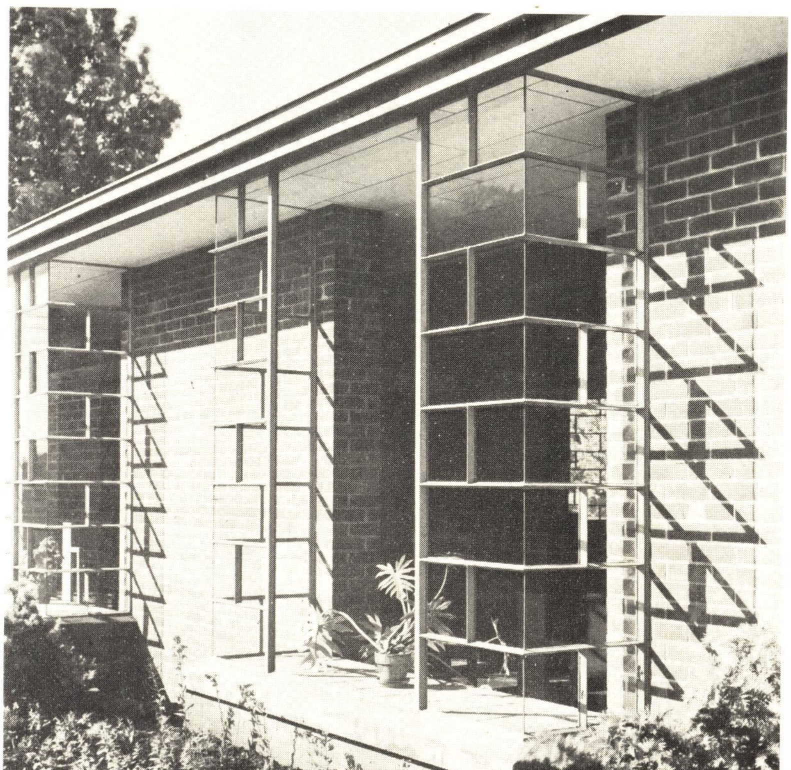
HORIZONTAL SECTION THROUGH ENTRANCE

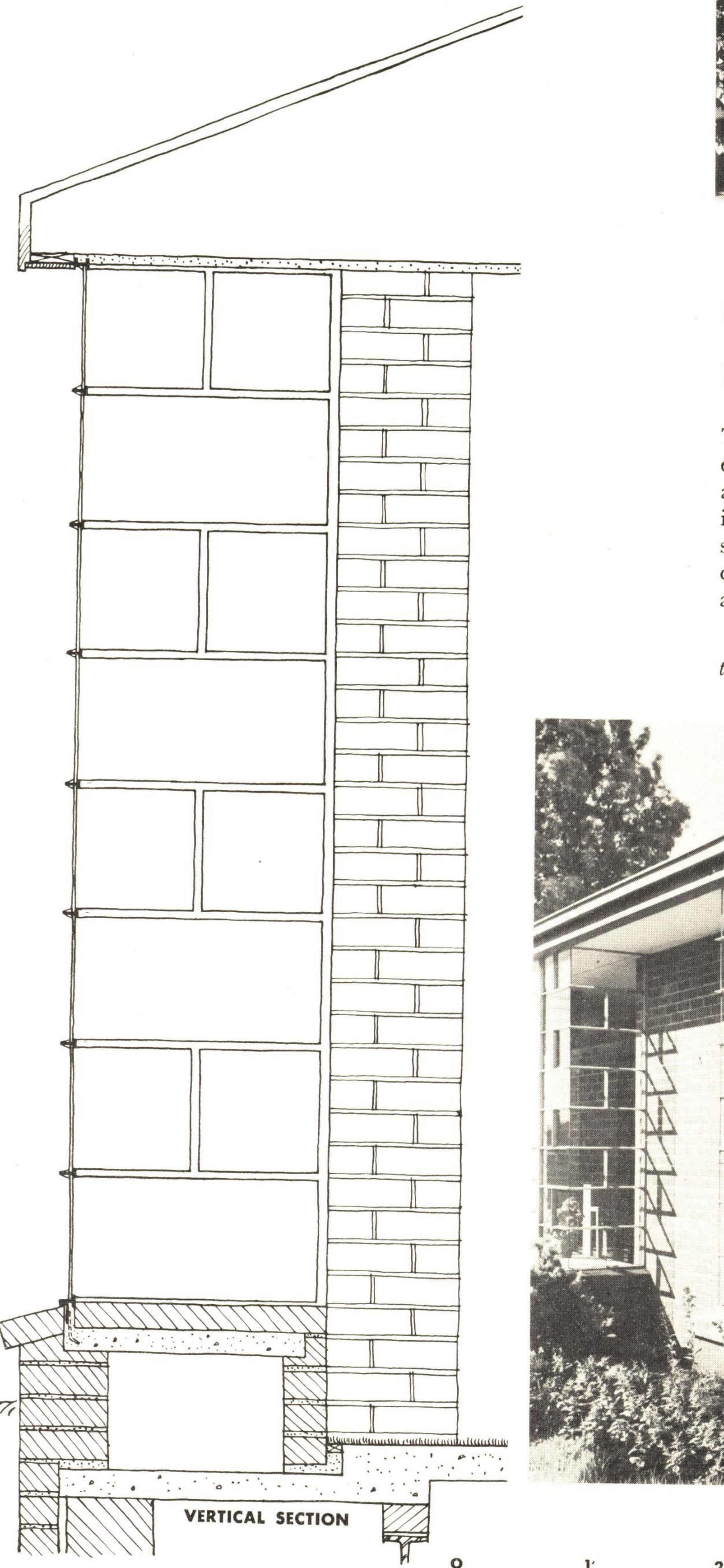


BAY WINDOWS IN MIDDLE-WEST CHURCH

The light cage-like elegance of these windows is emphasized by contrast with the solid brickwork and by the absence of corner mullions. The glass is mitered at these corners. The muntins, of T-shape standard metal sections, form a pattern which is original yet at the same time within the current of a long tradition of religious symbolism.

Reorganized Church of Latter Day Saints: *Architect:* Alden B. Dow. *Location Midland, Mich.*





BAY WINDOWS IN MODERN DRESS

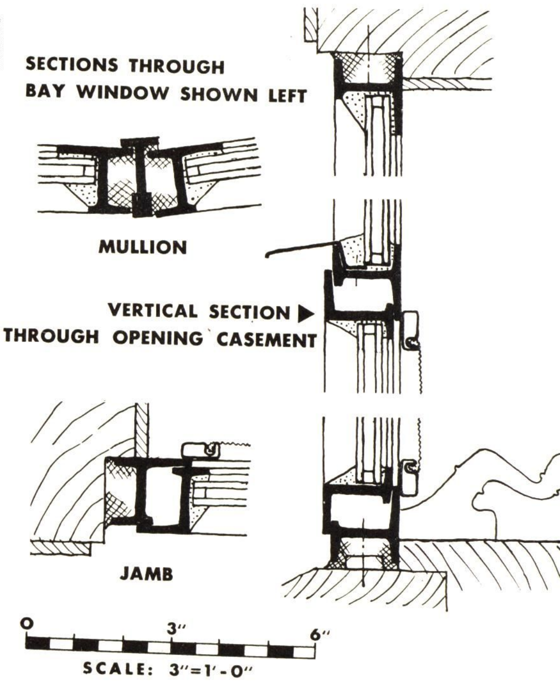
The bay window retains an old-established charm, a friendly outgoing to the view, even though it is made of sealed double glass in stock steel sash (bottom of page), even though it has wooden ventilating panels in the returns on each side, as in the sunny, intimate dining alcove below.

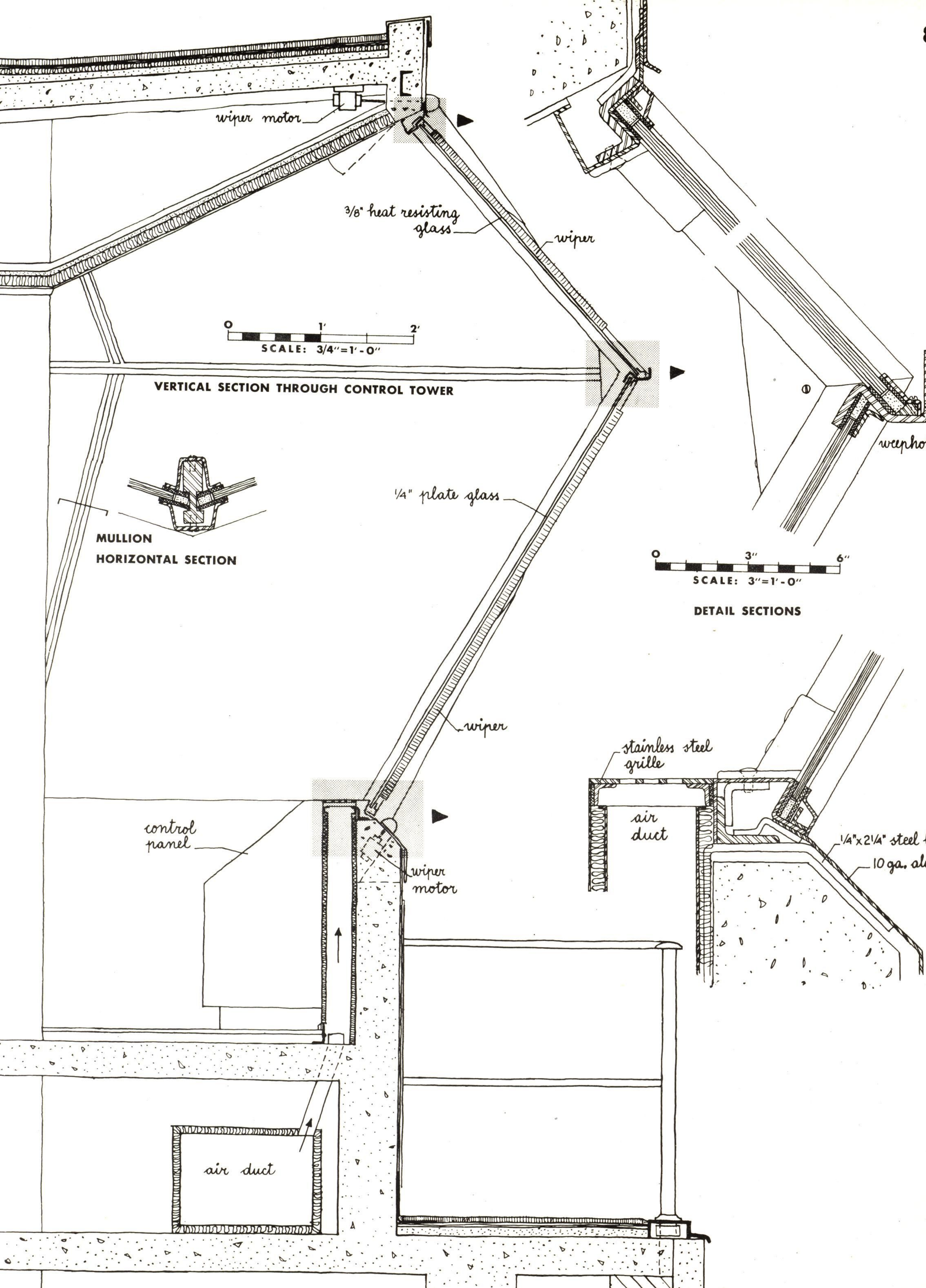
BELOW: *Architect:* G. Kosmak. *Location:* Ridgefield, Conn. BOTTOM OF PAGE: Norcross House. *Architect:* J. Gregory. *Location:* Dobbs Ferry, N. Y.

CONTROL TOWER: BAY WINDOW FOR AIR AGE

The primary need in a control tower is for a wide view both in a horizontal and vertical plane, unhindered by structural members or reflections. The framing of this light metal cage has been limited to thin posts in the center. The glass is set at the best angle for direct view without reflections. Motor-operated wipers keep it clear on the outside, a continuous hot air outlet along the sill inside wards off condensation fog. To cut sun heat the upper, skyward section is glazed with heat-resisting glass; its blue-green hue also cuts glare.

Washington National Airport. *Architects:* Public Buildings Administration; Howard L. Cheney, consultant. *Location:* Gravelly Point, Va.

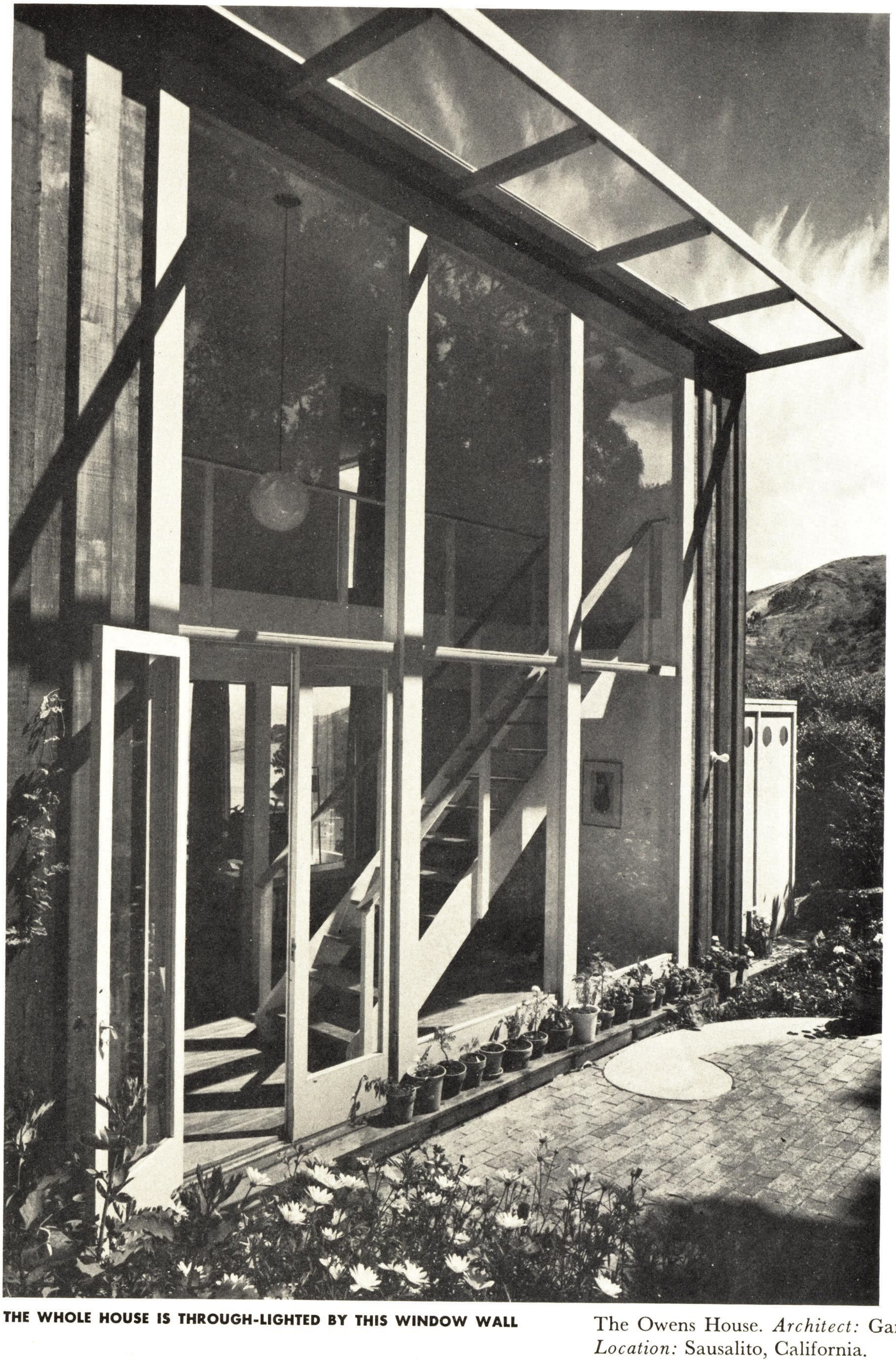




VERTICAL SECTION THROUGH CONTROL TOWER

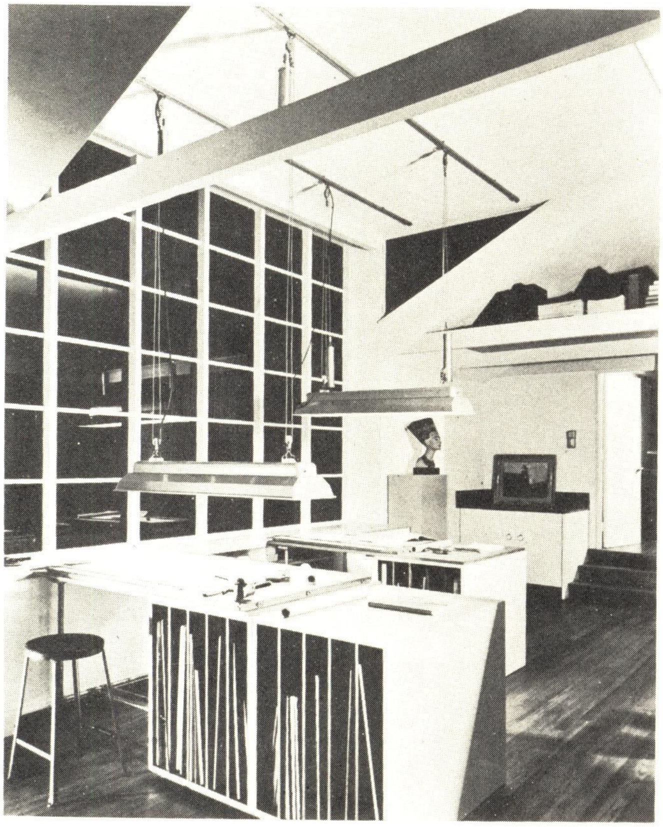
MULLION HORIZONTAL SECTION

DETAIL SECTIONS

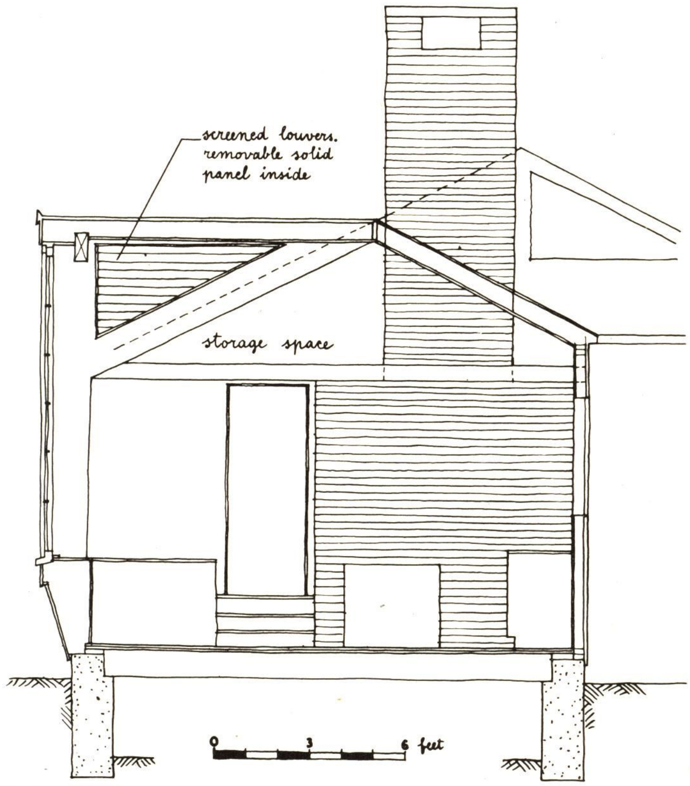


THE WHOLE HOUSE IS THROUGH-LIGHTED BY THIS WINDOW WALL

The Owens House. *Architect:* Gardner A. Dailey. *Location:* Sausalito, California.



INTERIOR OF THE STUDIO-DRAFTING ROOM AT NIGHT

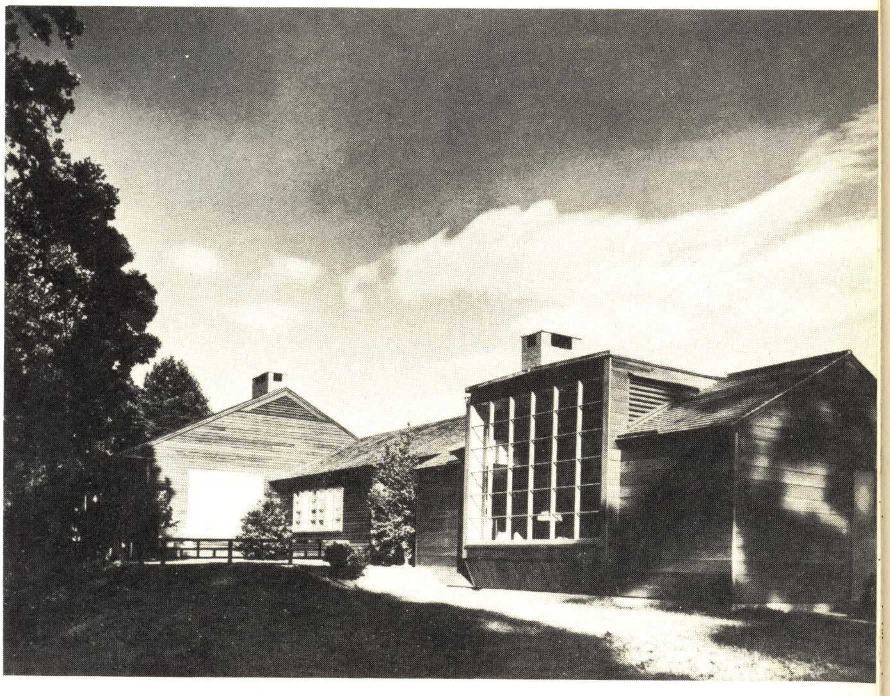


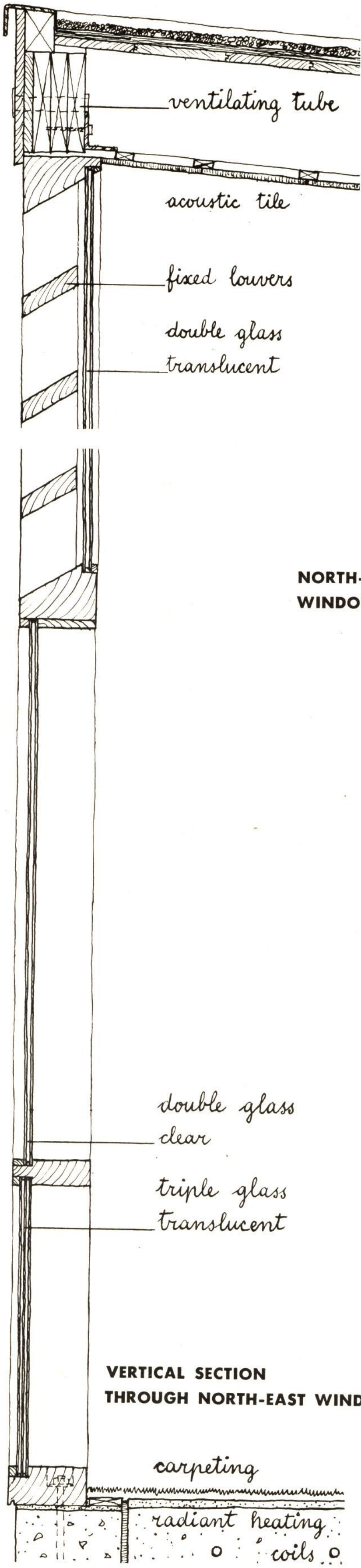
CROSS-SECTION THROUGH THE STUDIO-DRAFTING ROOM WING. HIGH LOUVERS GIVE ADDED, FLUE-ACTION VENTILATION IN SUMMER

FIXED SASH : TWO APPROACHES

Summed up in the two windows shown on this and the opposite page are two fundamentally different approaches to the design of large fixed sash. In the studio-drafting room shown on this page the big fixed sash is in reality a Brobdingnagian dormer. It is a window in the traditional sense (except for the lack of opening vents) which has been thrust out from the body of the house to increase the light and space within. In the Californian house opposite the window wall is constructed just like any other wall of the house, except that the space between the framing members (now revealed in their solid, carpenter logic) is not filled with sheets of opaque material but with sheets of glass, a most economical way of creating windows. Curtains are not necessary here; this side of the house faces into the hill and cannot be overlooked.

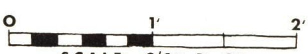
Studio-drafting room. *Architects:* Victorine & Samuel Homsey (their own house). *Location:* Hockessin, Del.



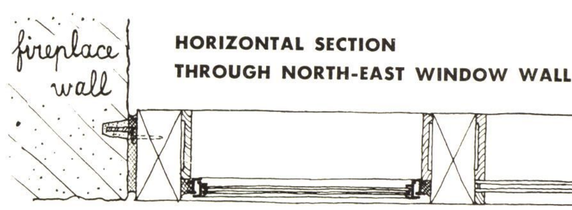


VERTICAL SECTION
THROUGH NORTH-EAST WINDOW WALL

NORTH-EAST ▶
WINDOW WALL



SCALE: 3/4"=1'-0"



HORIZONTAL SECTION
THROUGH NORTH-EAST WINDOW WALL

TWO OPPOSITE LONG SIDES OF THE LIVING ROOM ARE WINDOW WALLS

TRANSLUCENT GLASS FOR LIGHT, CLEAR GLASS FOR VIEW

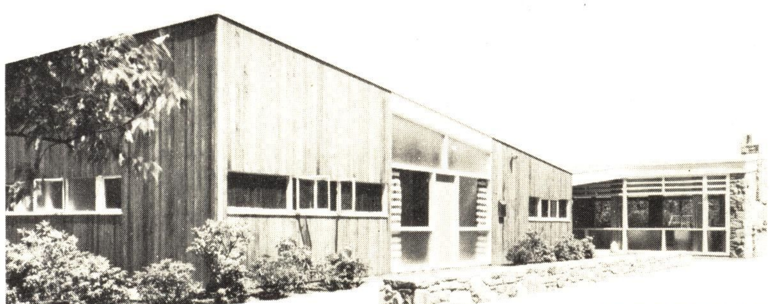
This living room is in a separate projecting wing, with a stone fireplace wall at the end, window walls on the two long sides, which face north-east and south-west on a private garden.

These glazed walls are divided into three horizontal bands. The center one is of clear plate for view, the top and bottom ones of translucent glass for light diffusion. Fixed louvers in the top section eliminate glare. Standard steel casements at the fireplace end of each wall provide ventilation.

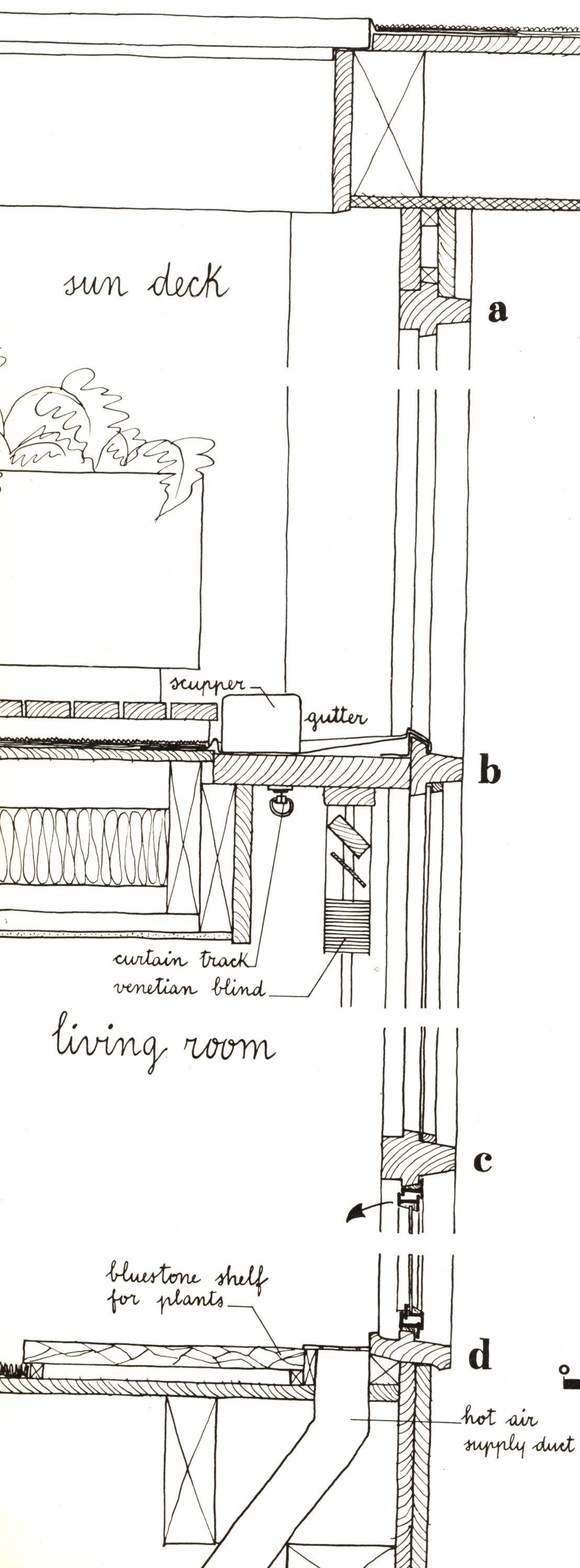
These window walls are notable for the way in which they provide abundant, but evenly diffused daylight without uncomfortably sharp contrasts. The garden view is accentuated by being limited, framed within the clear glass band.

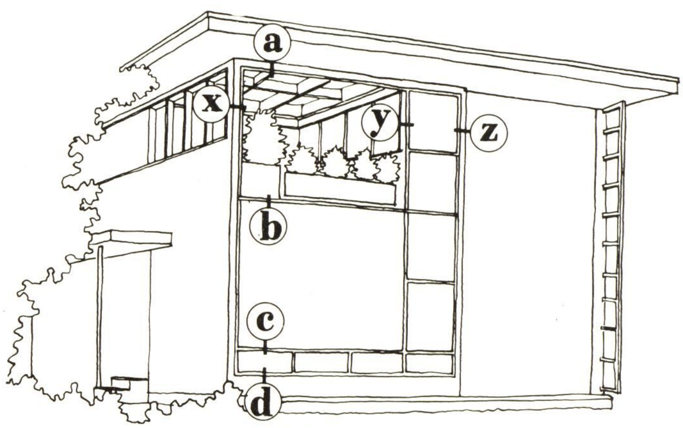
Without sacrifice of light and view, this type of fenestration succeeds in maintaining a feeling of intimacy and shelter which is often lacking in rooms with large areas of glass wall.

The Geller House. *Architect:* Marcel Breuer. *Location:* Lawrence, Long Island, N. Y.



LIVING ROOM WING



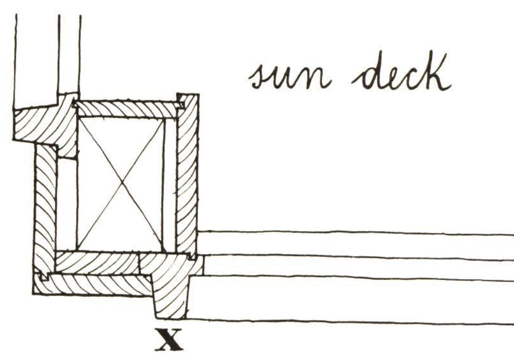


KEY TO SECTIONS OF SOUTH FRONT

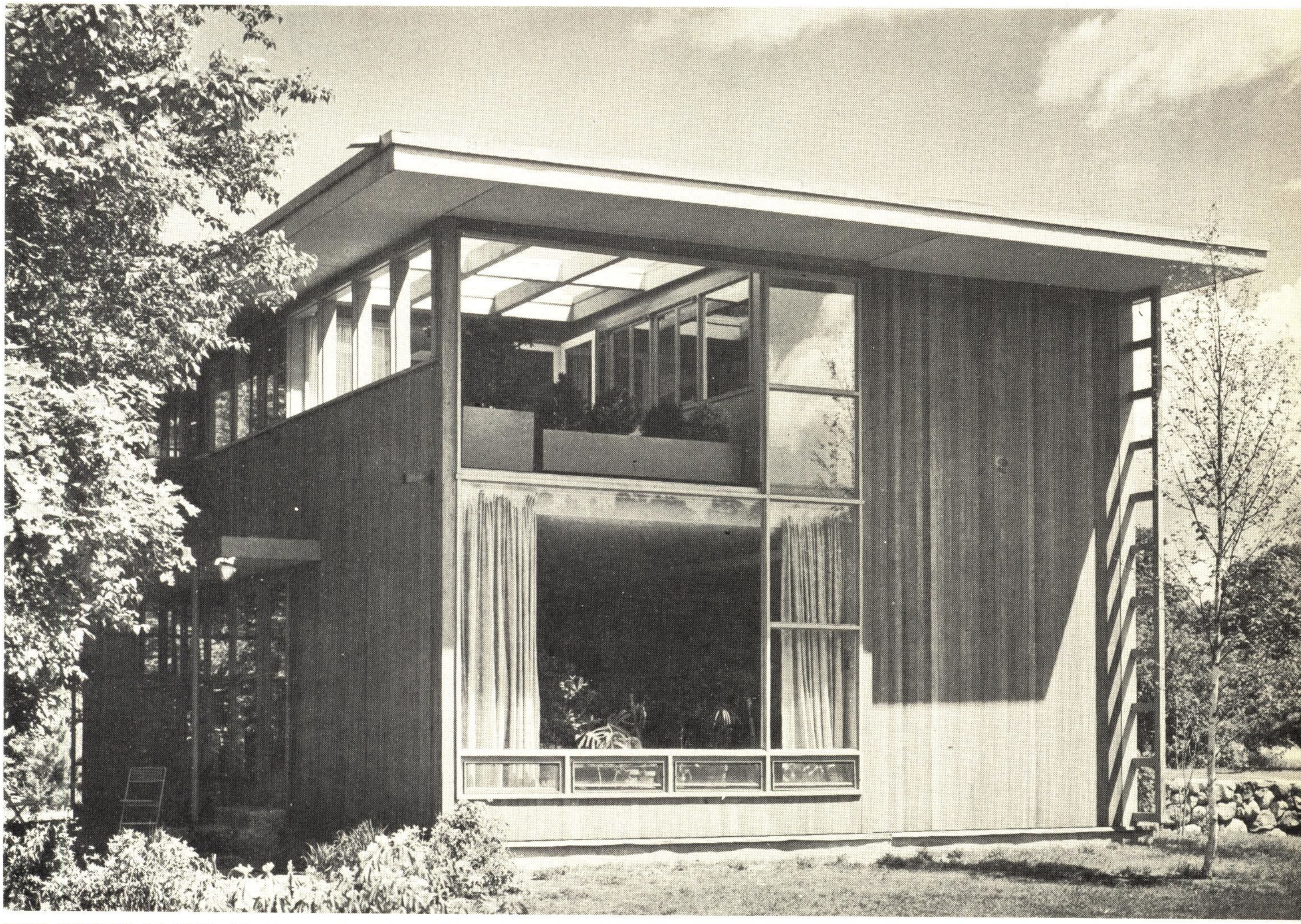
◀ VERTICAL SECTION

BELOW:

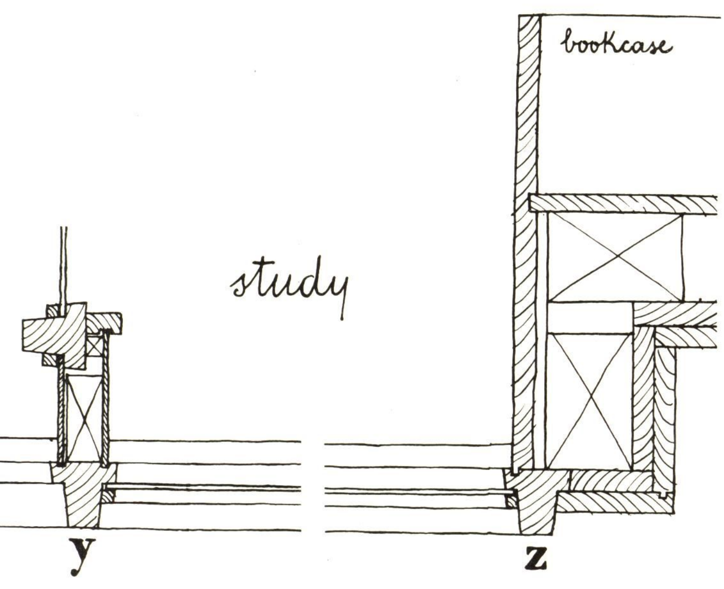
HORIZONTAL SECTION AT SECOND FLOOR



SCALE: 1½"=1'-0"



THAT PRIVACY AS WELL AS OPENNESS WAS WANTED IS CLEARLY SHOWN IN THIS SOUTH FRONT OF THE HOUSE



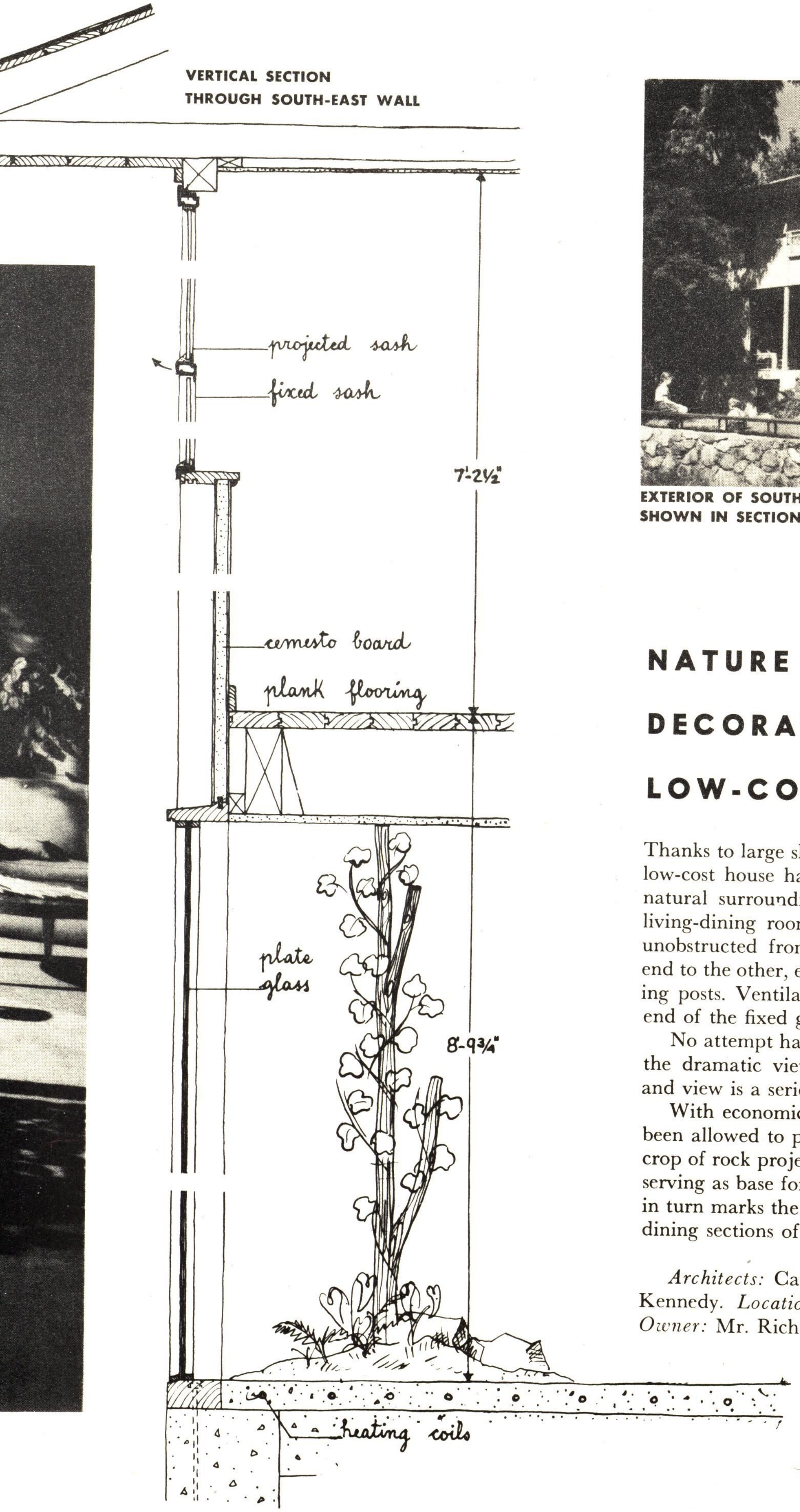
WINDOWS MAY BE LEFT UNGLAZED

The sun deck here, above the living room, is just as much a room with windows (and skylight) as the more conventionally enclosed rooms around it. The window frames are there, identical in section with those adjoining, but in the sun deck walls they are unglazed. This is consistent with the very conscious, "painterly" arrangement of rectangles on the surface of the building, and the equally conscious interplay of solid mass and opened space. Mechanically also the house is well considered, for one example warm and fresh air both introduced at the base of the living room window.

Architect and Owner: Walter F. Bogner. *Location:* Lincoln, Massachusetts.

A PLATE GLASS MEMBRANE VISUALLY DISSOLVES THE SOUTH-EAST WALL OF THIS ROOM

VERTICAL SECTION THROUGH SOUTH-EAST WALL



EXTERIOR OF SOUTH-EAST WALL SHOWN IN SECTION AT LEFT

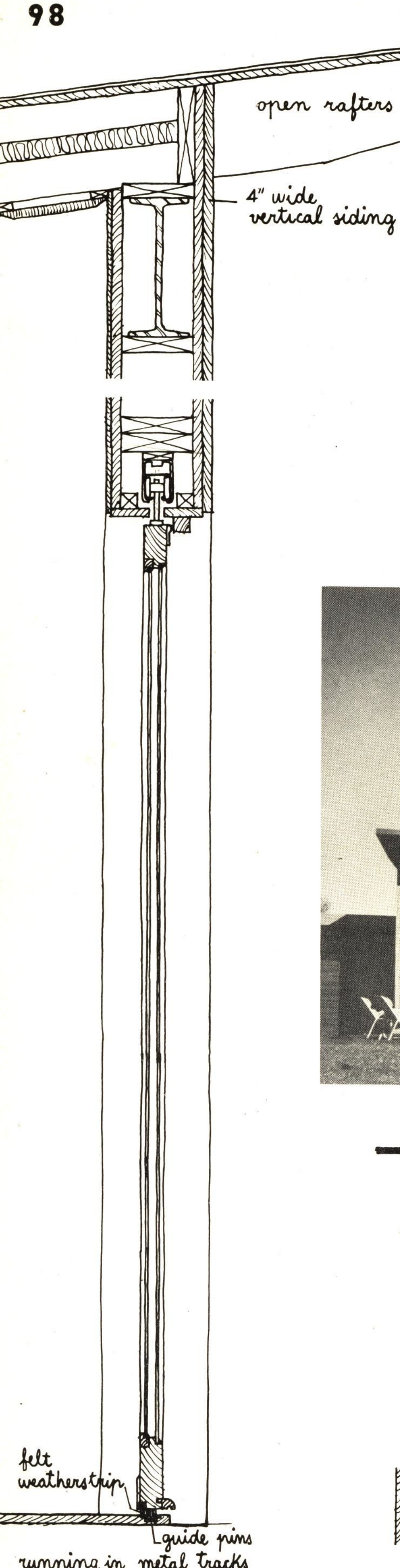
NATURE USED AS DECORATOR IN THIS LOW-COST HOUSE

Thanks to large sheets of glass the simplicity of this low-cost house has been enriched by its luxurious natural surroundings. The south-east wall of the living-dining room is largely of clear plate glass, unobstructed from floor to ceiling and from one end to the other, except for four intermediate framing posts. Ventilation is by projected sash at each end of the fixed glass section (see exterior above).

No attempt has been made to "architecturalize" the dramatic view. The only control of daylight and view is a series of floor-to-ceiling curtains.

With economical appeasement, nature has even been allowed to penetrate the house itself. An outcrop of rock projects through the living room floor, serving as base for a vine-covered tree trunk which in turn marks the boundary between the living and dining sections of this room.

Architects: Carl Koch, Huson Jackson, Robert Kennedy. *Location:* Snake Hill, Belmont, Mass. *Owner:* Mr. Richard Kriebel.

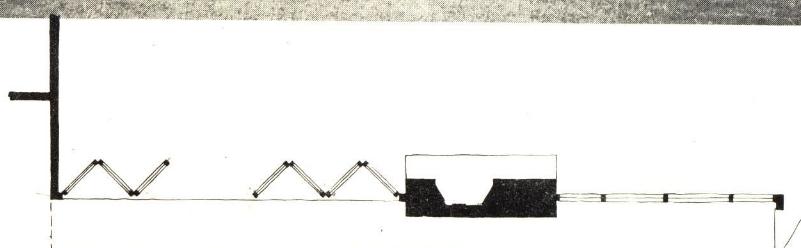


VERTICAL SECTION THROUGH ACCORDION SASH

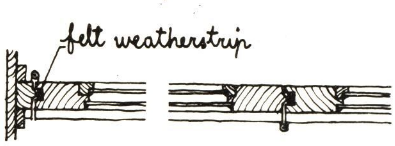
THE WINDOW WALL THAT FOLDS AWAY

With disappearing window walls the question always is: whither can we make it disappear? Sliding sash need wall pockets to give a completely clear opening. Here there was no place for pockets — stone chimney at one end, end wall at the other — so floor-to-ceiling accordion sash was the inevitable choice. The door-wide segments project inwards; there are removable screens on the outside face of the wall. Head and sill joints are most carefully weatherstripped; also the hinged vertical joints.

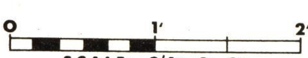
Architect: Eaton W. Tarbell & Associates. *Location:* South Brewer, Maine. *Owner:* Eastern Corp.



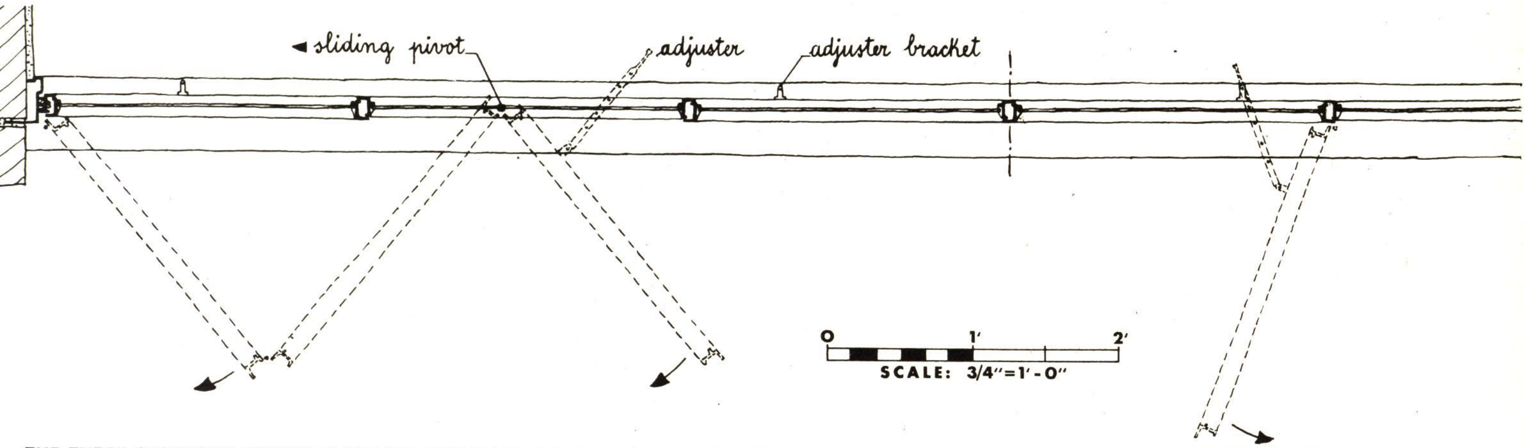
DIAGRAMMATIC PLAN OF WALL PICTURED ABOVE



HORIZONTAL SECTION THROUGH ACCORDION SASH



SCALE: 3/4"=1'-0"

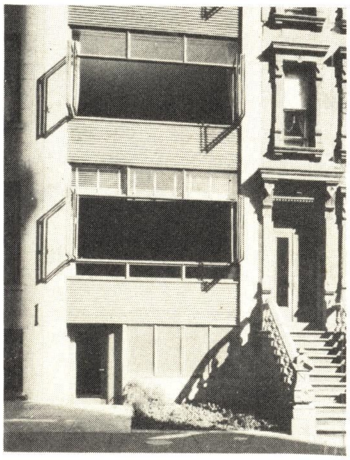


THE THREE SEGMENTS WHICH MAKE UP ONE HALF OF EACH COMPLETE WINDOW MAY BE FOLDED AND SLID UNTIL THEY ARE STACKED AWAY AGAINST THE JAMB AS SHOWN IN THE PHOTO AT RIGHT BELOW.

OR THE TWO CENTER SEGMENTS MAY BE OPERATED LIKE STANDARD CASEMENTS

ACCORDION SASH CLOSED

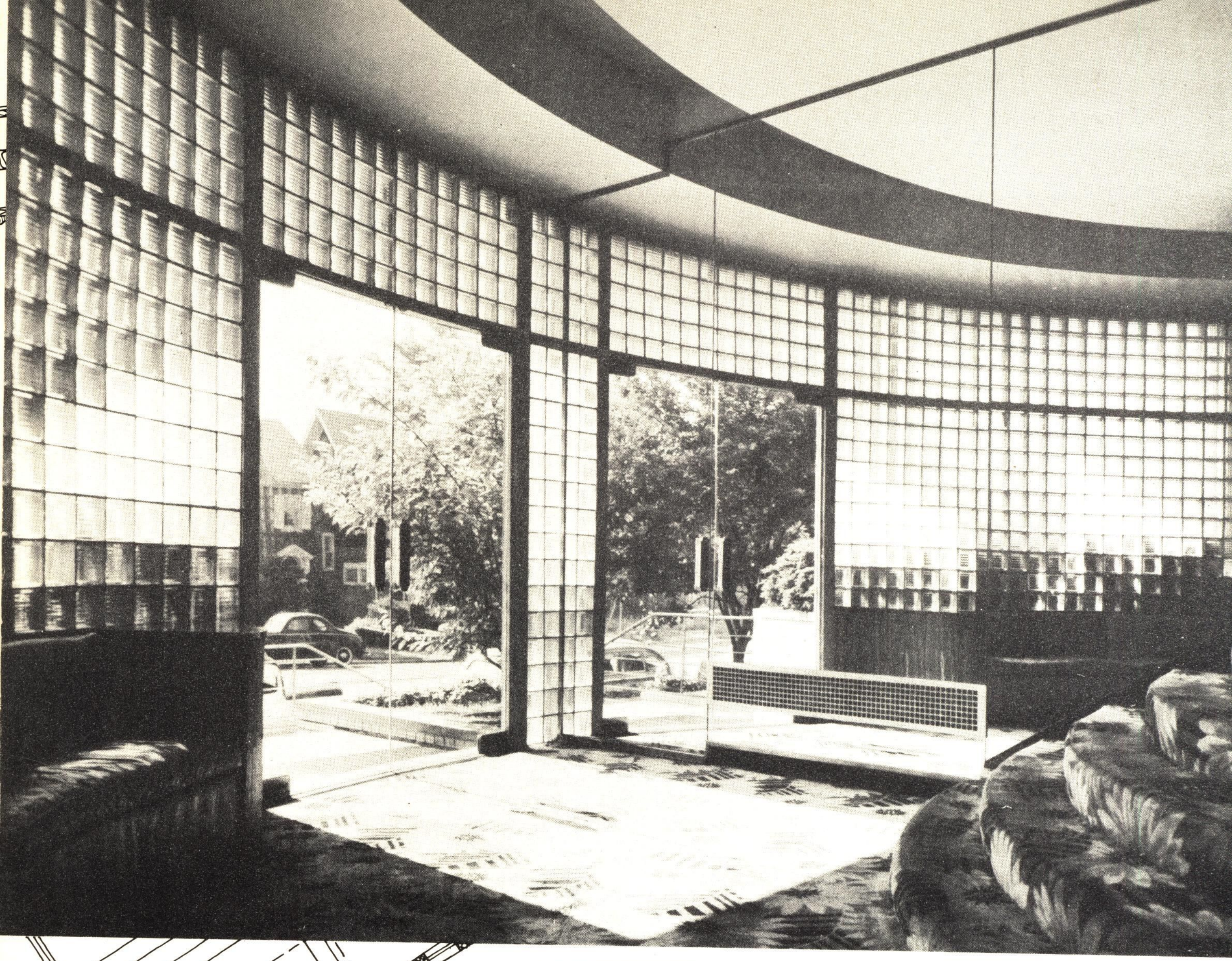
ACCORDION SASH OPEN

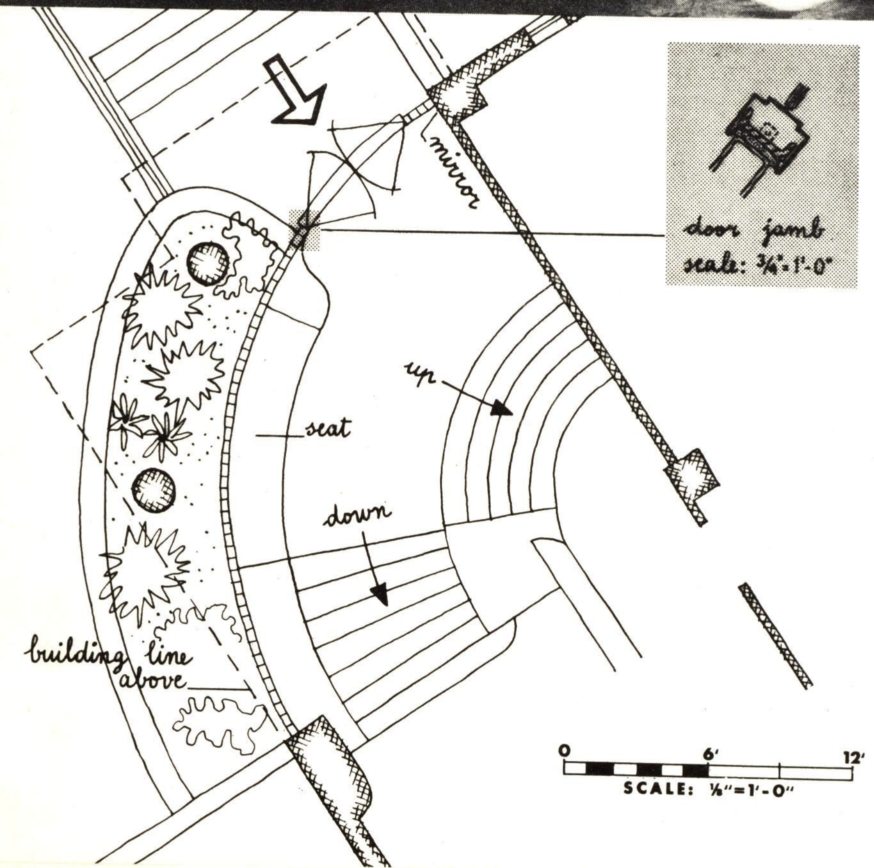


ACCORDION WINDOWS IN OLD BROWNSTONE

One of New York's old brownstone row houses—a brother to that on the right side of the picture—has had its southern (street) front scraped clean and opened to the breeze with accordion windows. Custom-made with stock sections, these give a completely clear opening across the whole width of the building. This wide-opening front is in strong contrast to most such remodeling (cf. page 101) which attempts to shut out the street with a fixed, translucent glass screen. Corrugated aluminum in the strips between the windows here gives a clean, horizontal finish. The entrance has been moved to the first floor, where the sash have translucent glass for the sake of privacy.

Architects: Sanders & Breck, Smith Miller, assoc.

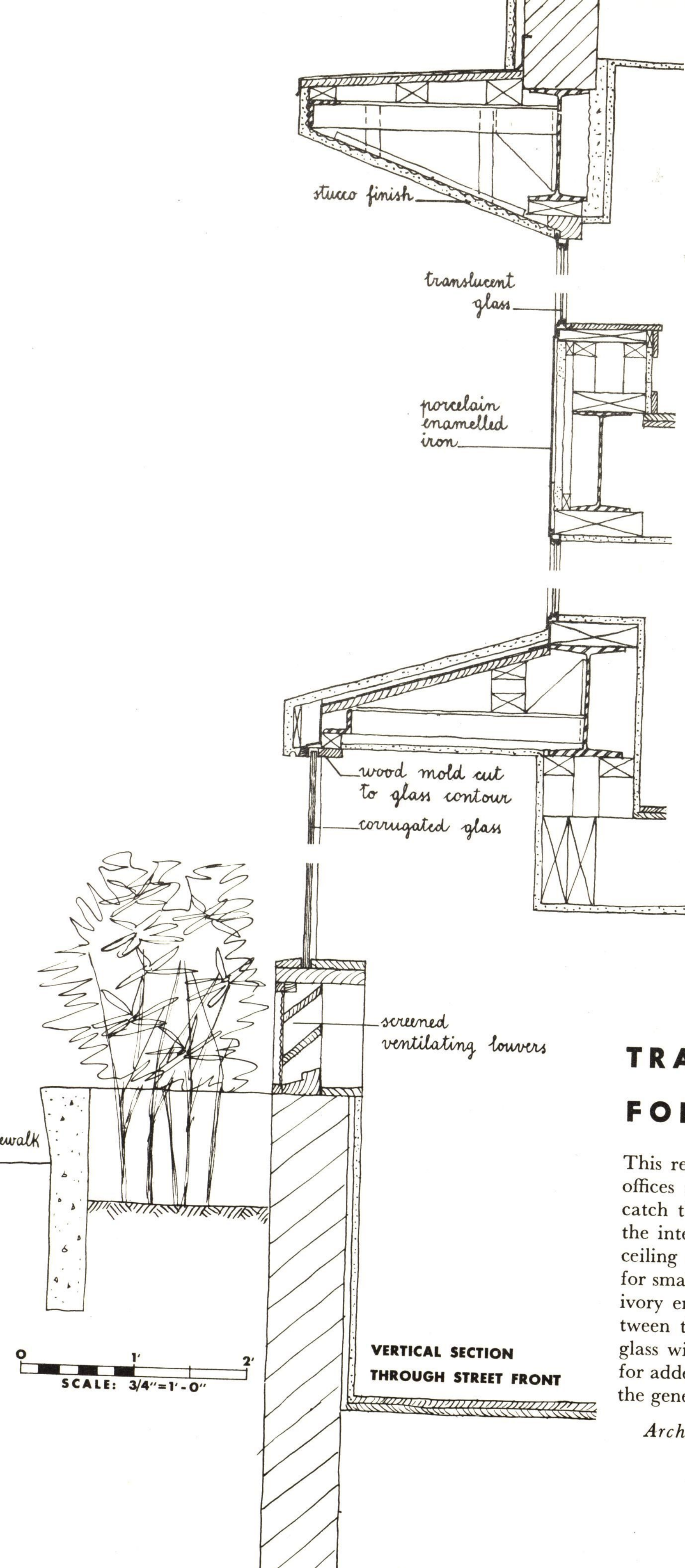




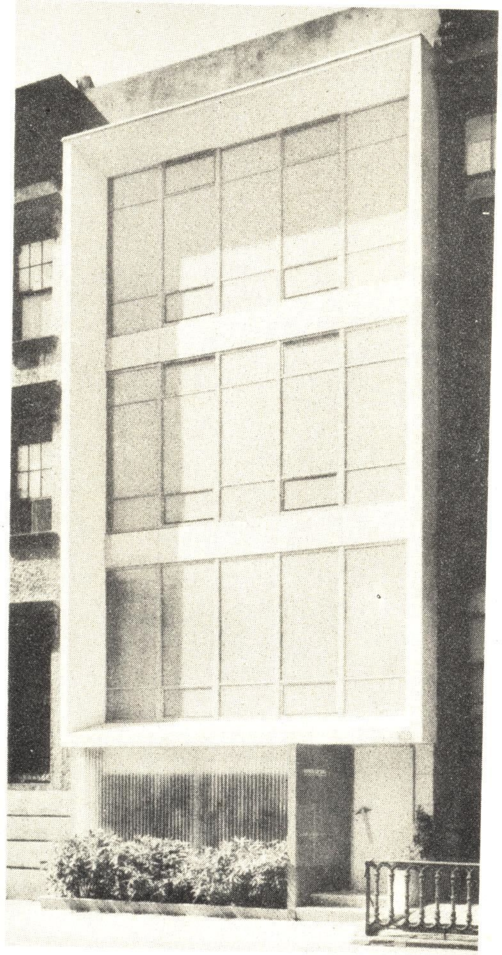
GLASS BLOCK FOR APARTMENT HOUSE

A curving outside wall of glass block with frameless, tempered glass doors, and also one inside wall entirely of mirror glass, combine to flood this apartment house lobby with a pleasantly bright and even light. Such a shimmer of light, when added to the curving walls and changing levels (multiplied again by the mirror), helps to confuse the true size and shape of the various elements which together make up the picture. And thus the architects skillfully disguise the lobby's small size and awkward shape.

Architects: Berla & Abel. *Location:* Washington, D. C. *Owner:* Mr. Henry Jawish.



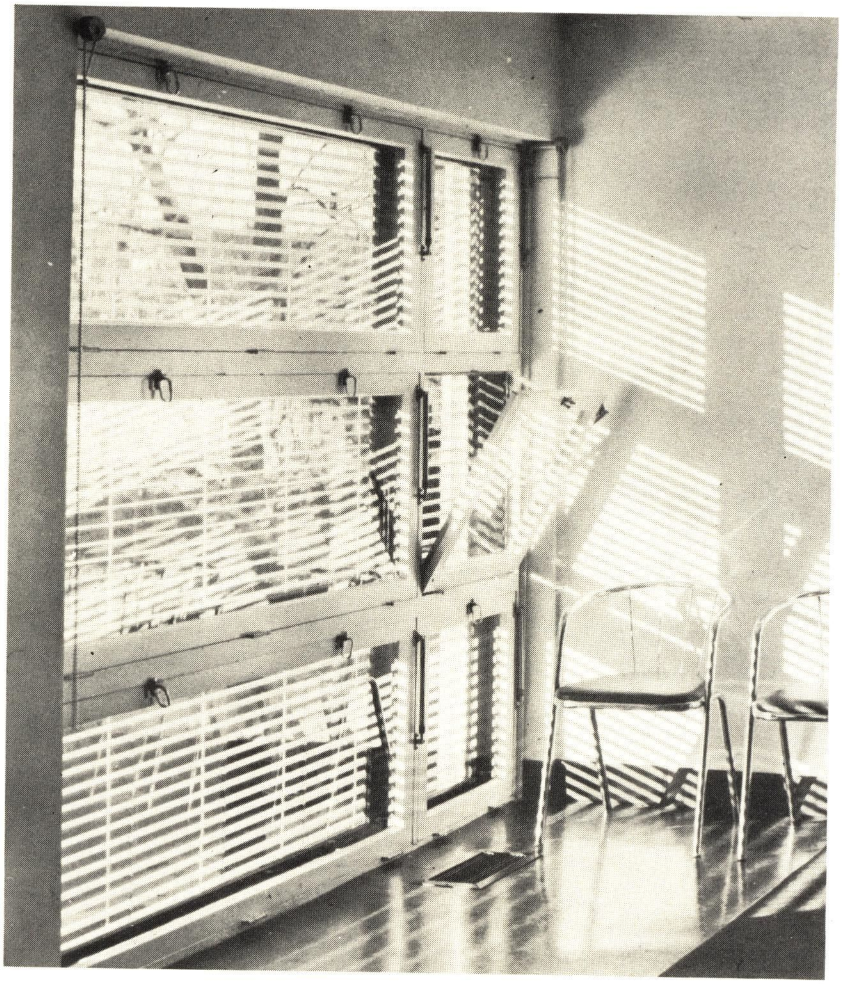
VERTICAL SECTION THROUGH STREET FRONT

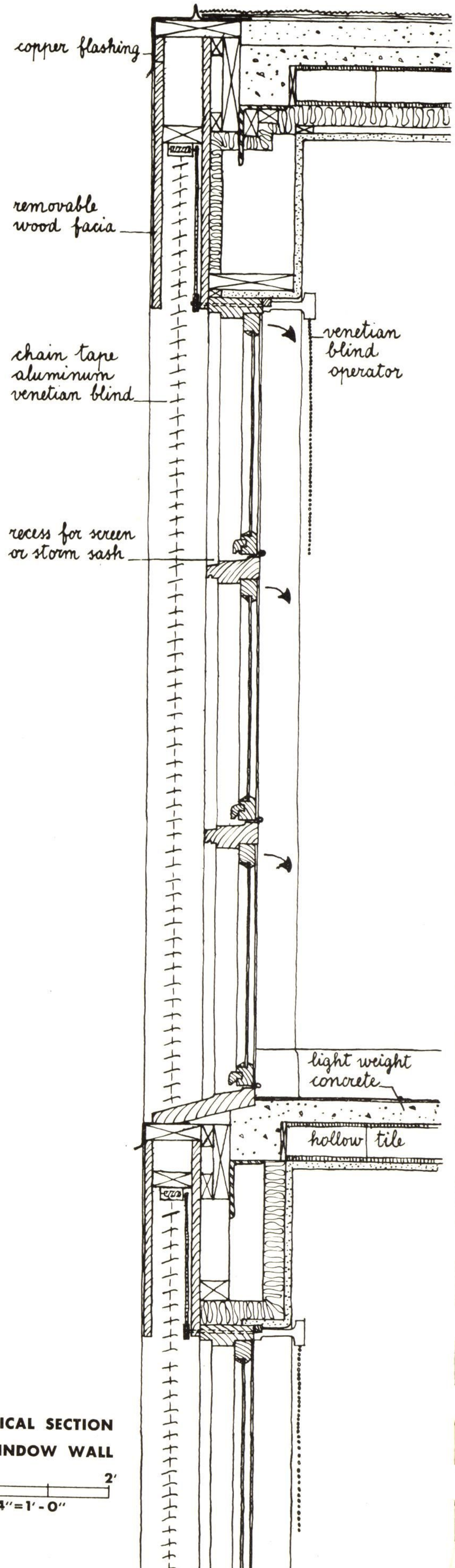


TRANSLUCENT GLASS FOR TOWN HOUSE

This remodeled New York brownstone houses the offices and drafting rooms of three designers. To catch the maximum amount of daylight, yet shut the interior off from the street, there are floor-to-ceiling windows of translucent glass, fixed except for small ventilators top and bottom. Sheets of pale ivory enameled iron cover the spandrel strips between the windows. On the first floor corrugated glass with louvered vents is used for security, and for added light this window pocket continues above the general ceiling level of the large drafting room.

Architect and Owner: Morris Lapidus.





EXTERIOR VENETIAN BLINDS CONTROL SOLAR HEAT, LIGHT

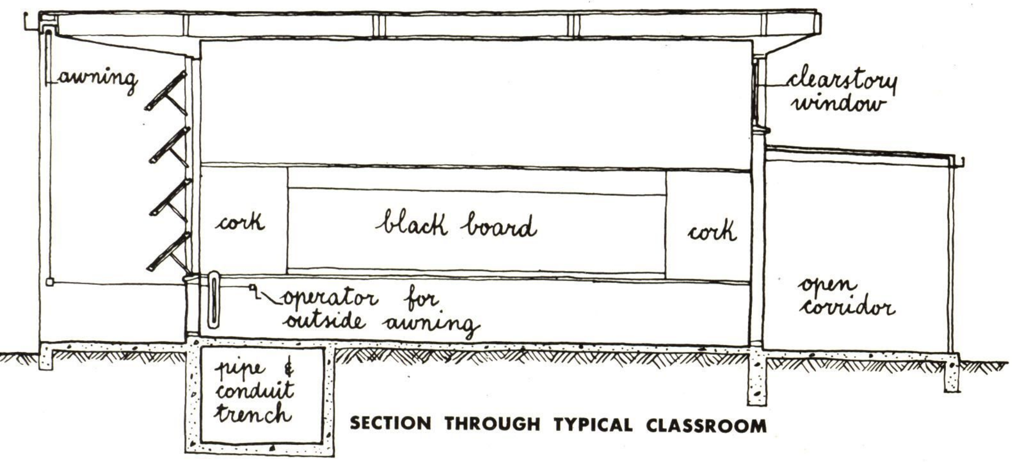
Placed outside the windows of this Chicago apartment house, these aluminum Venetian blinds are effective in controlling the sun's heat as well as its light. They intercept heat rays which would hit the glass of the window and re-radiate within the house. This type of blind, with chain tapes, is capable of withstanding the weather, and still gives that pleasant sparkle of broken light in the room which is typical of all Venetian blinds. It is controlled from inside the house, and when drawn up it is hidden and protected in a pocket above the level of the window head. Bottom-hinged, in-swinging vents give moderately weatherproof ventilation.

Small apartment house. *Architect:* George Fred Keck. *Location:* Chicago, Illinois.

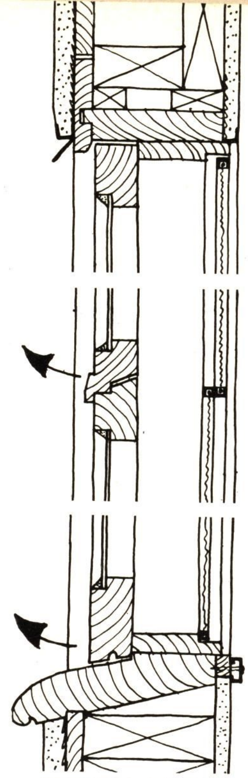
VERTICAL SECTION THROUGH WINDOW WALL

0 1' 2'

SCALE: 3/4"=1'-0"



SECTION THROUGH TYPICAL CLASSROOM

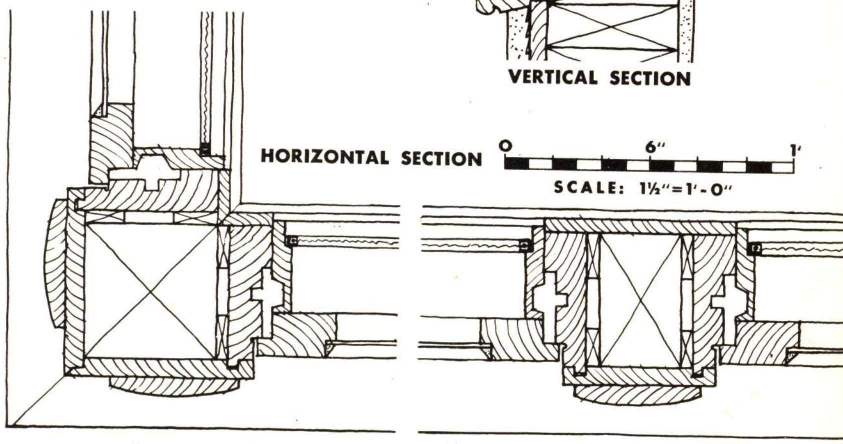


VERTICAL SECTION

OVERHANG PLUS AWNING AT EDGE

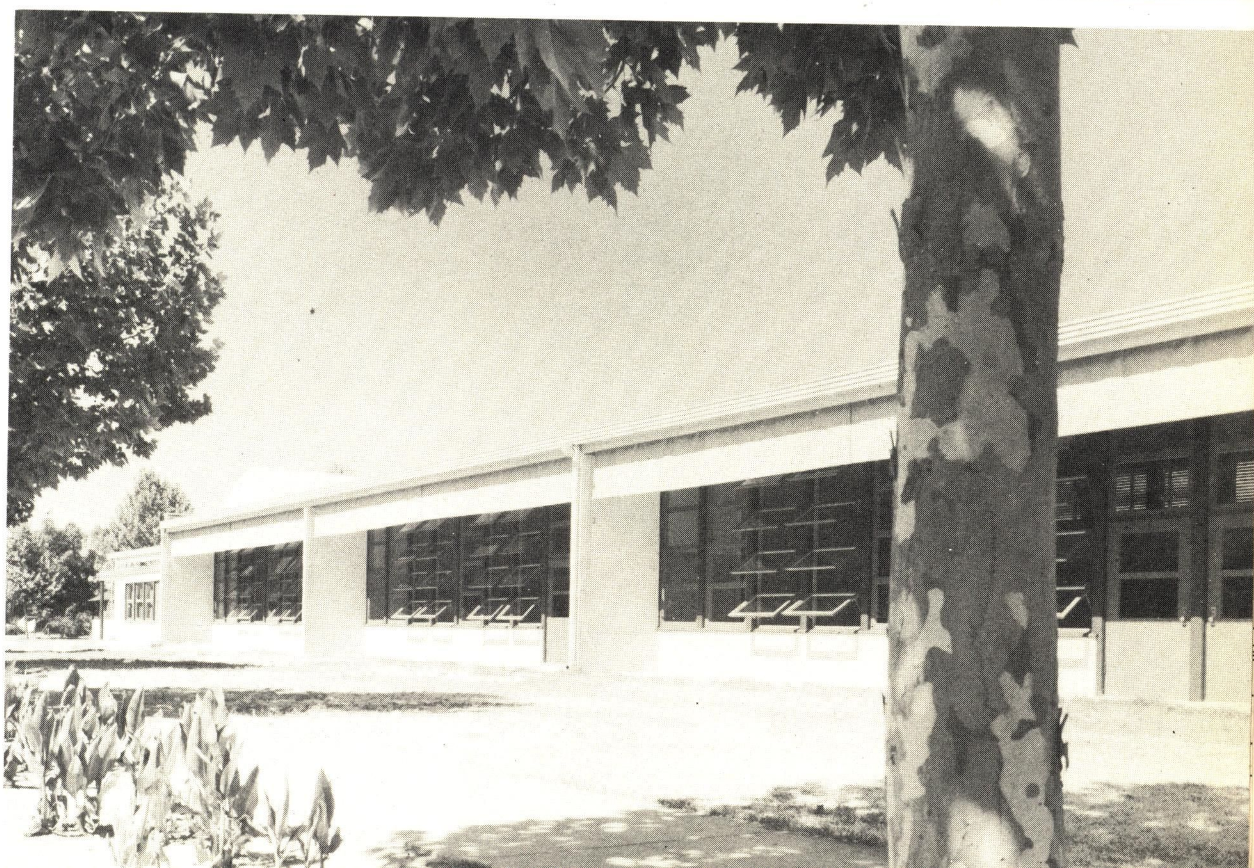
To increase the shading effect of a roof overhang, an awning (operated from inside the classroom) may be unrolled from its edge, allowing more flexibility of light control. The classroom lighting is typical of one-story California schools: a shaded window wall on one side, clearstory windows on the opposite wall above the corridor roof.

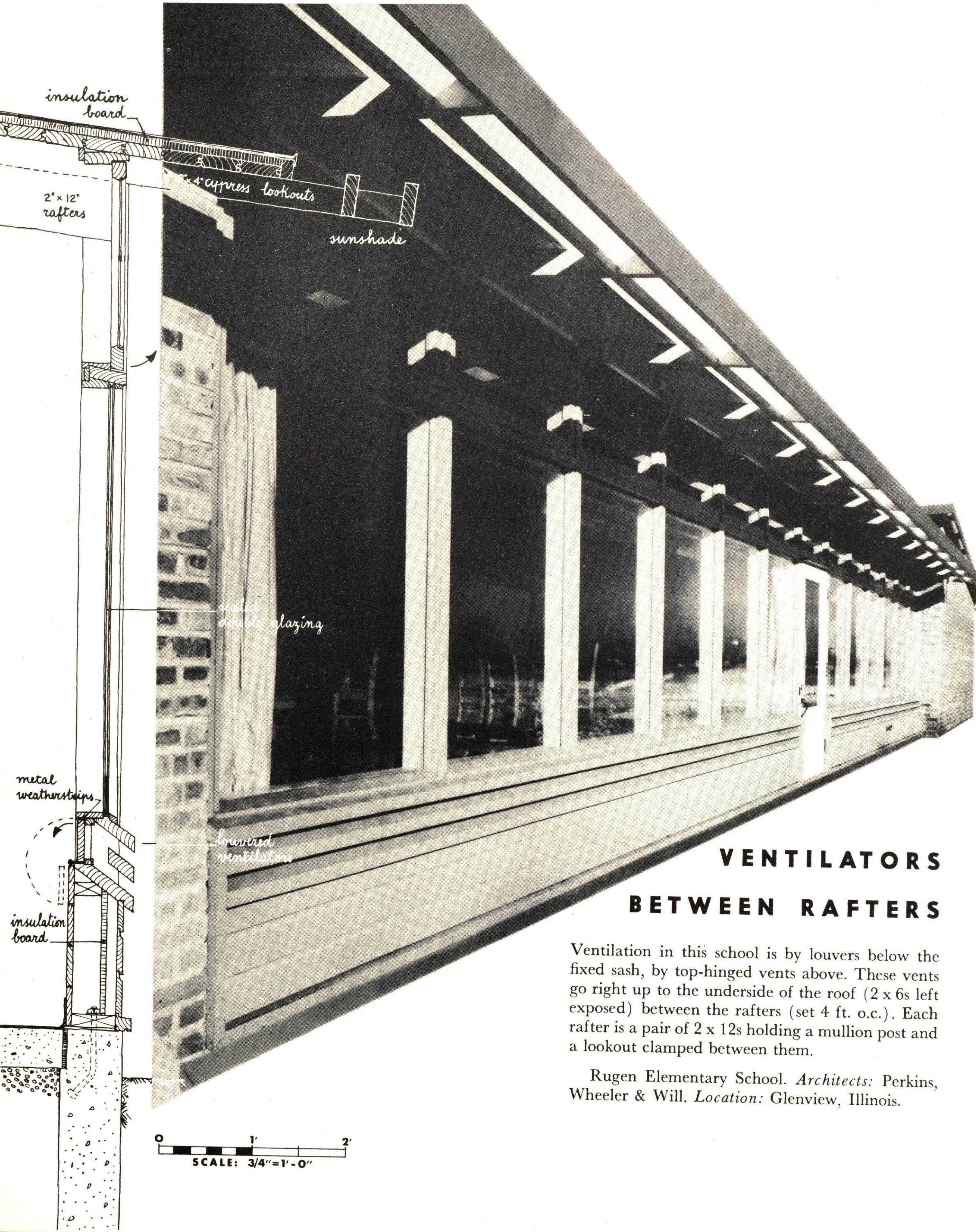
Elementary School. *Architects and Engineers:* Franklin, Kump & Falk. *Location:* Fowler, Calif.



HORIZONTAL SECTION

SCALE: 1½"=1'-0"





VENTILATORS BETWEEN RAFTERS

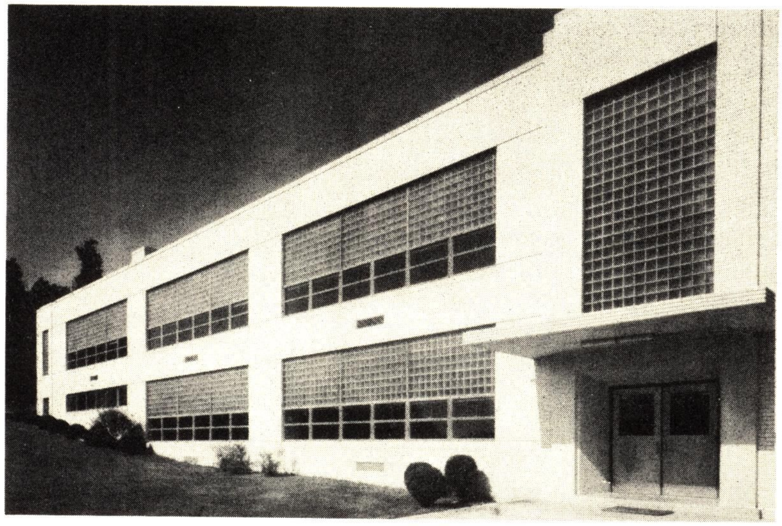
Ventilation in this school is by louvers below the fixed sash, by top-hinged vents above. These vents go right up to the underside of the roof (2 x 6s left exposed) between the rafters (set 4 ft. o.c.). Each rafter is a pair of 2 x 12s holding a mullion post and a lookout clamped between them.

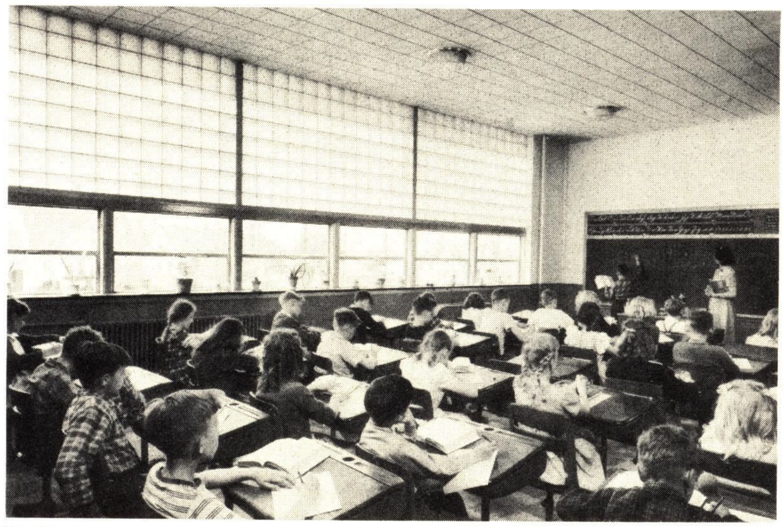
Rugen Elementary School. *Architects:* Perkins, Wheeler & Will. *Location:* Glenview, Illinois.

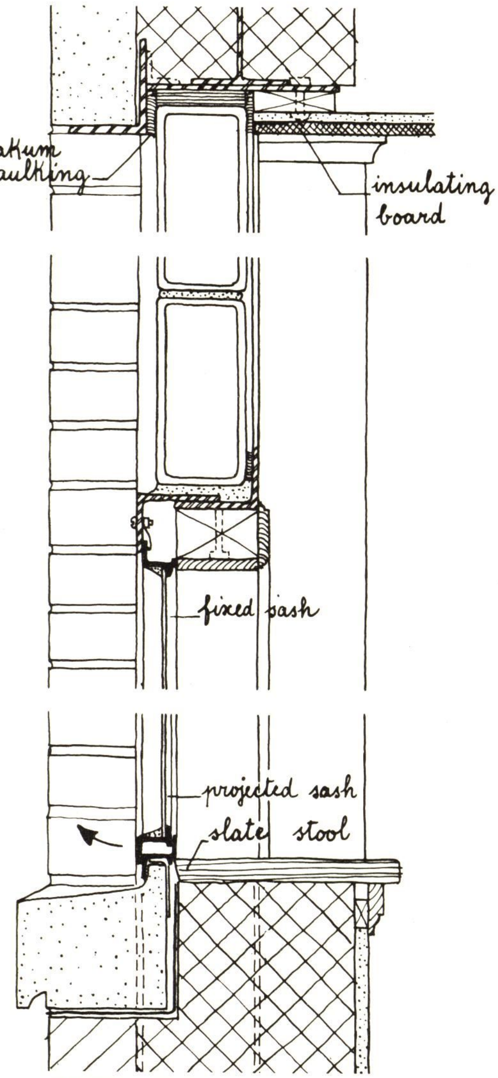
BLOCK BENDS LIGHT TO REACH BACK WALL

In a multi-story school building where the classrooms can be lighted from one side only, it has always been difficult to provide even illumination in all parts of the room. Prismatic glass block in the upper half of the window wall diffuse the light and bend it upward, throwing it further toward the back wall. A clear vision strip below the blocks allows the eyes a necessary change of focus. The construction details shown are now standard.

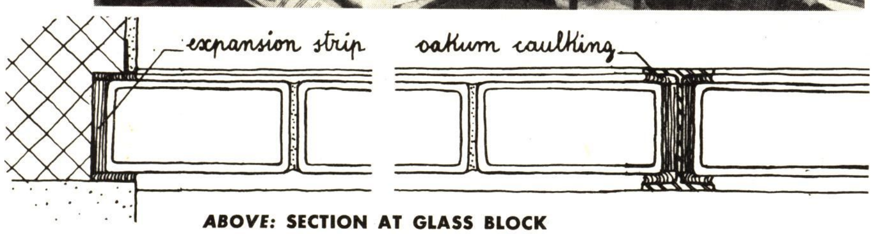
RIGHT TOP: Kensington High School, Md. *Architect:* Rhees E. Burket. RIGHT BELOW: Oakdale Christian School, Grand Rapids, Mich. *Architect:* J. K. Haveman.





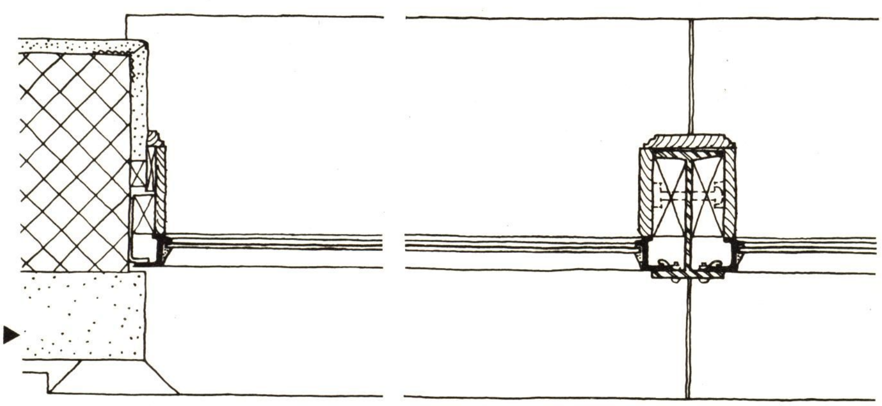


TYPICAL VERTICAL SECTION



ABOVE: SECTION AT GLASS BLOCK

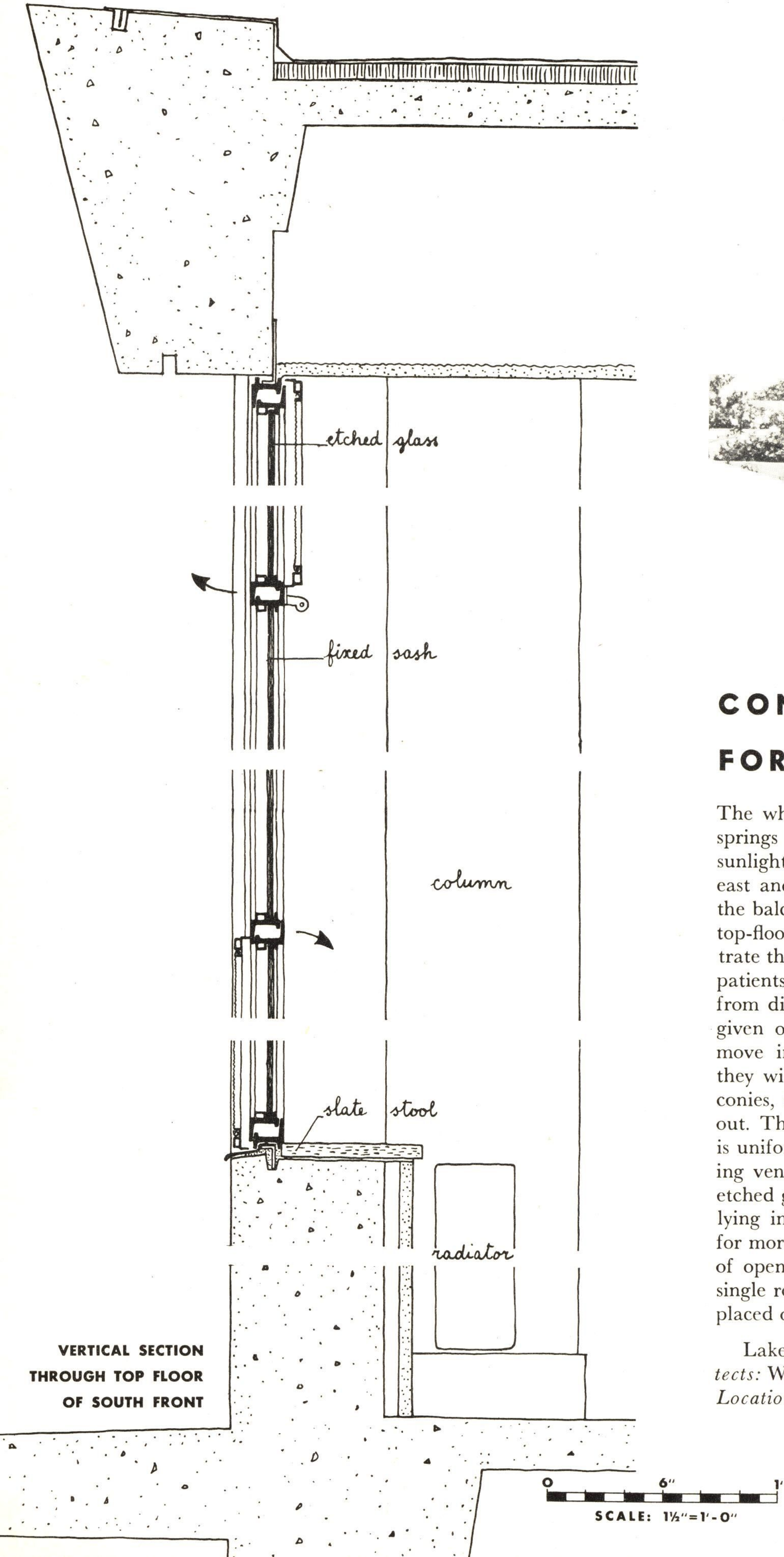
BELOW: SECTION AT FIXED SASH



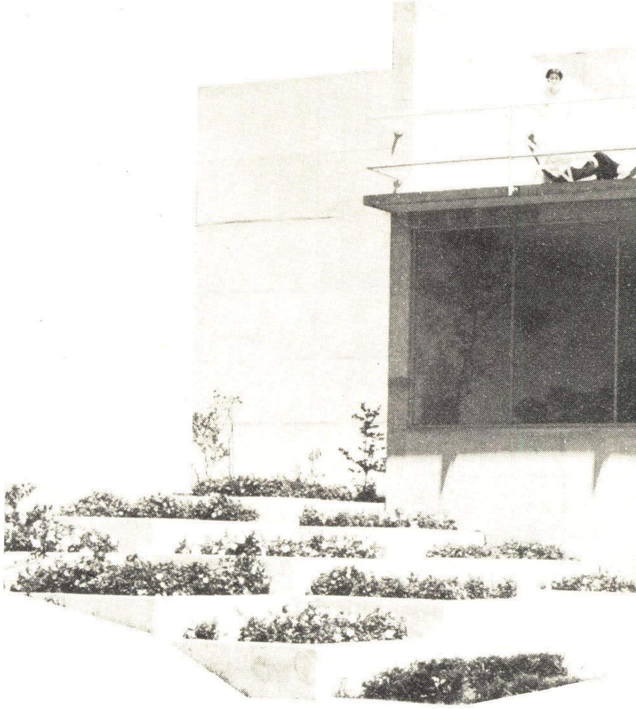
TYPICAL HORIZONTAL SECTION ▶

0 6" 1'

SCALE: 1½"=1'-0"



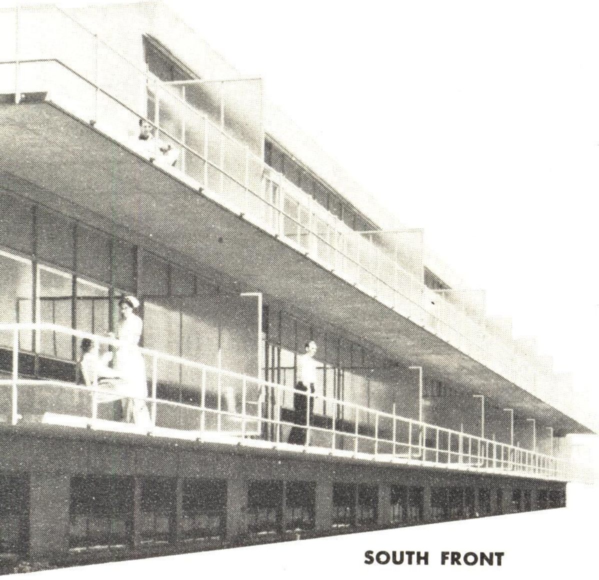
VERTICAL SECTION THROUGH TOP FLOOR OF SOUTH FRONT



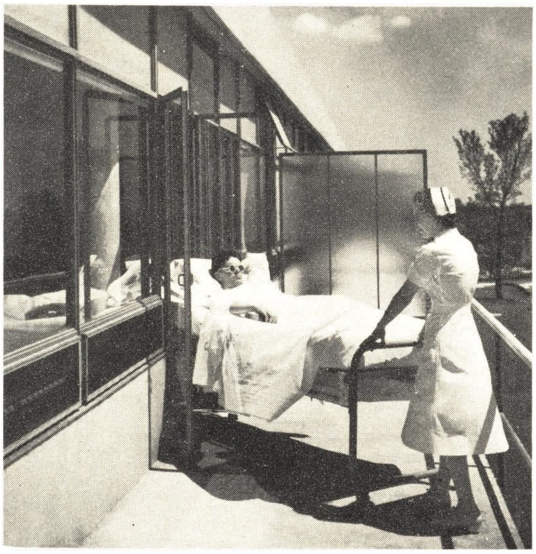
CONTROLLED SUNLIGHT FOR SANATORIUM

The whole design of this tuberculosis sanatorium springs from the needs of the patients — fresh air, sunlight, rest. It is a long, thin building which runs east and west, so that all the patients' rooms and the balconies in front of them face due south. The top-floor rooms, where direct sunlight can penetrate the interior, are for semi-ambulant and infirm patients. The rooms on the floor below, shielded from direct sunlight by the balcony overhang, are given over to ambulant patients, who can easily move into direct sunlight on the balcony when they wish. All rooms open directly on to the balconies, so that beds can be easily wheeled in and out. The window arrangement in all these rooms is uniform: a center band of fixed sash with opening vents above and below. The top vents are of etched glass to diffuse the light, especially for those lying in bed. Roller shades on the fixed sash are for more drastic light control. One further instance of open-minded planning in this building: a few single rooms, for the seriously ill, were deliberately placed on the north to avoid the sunlight.

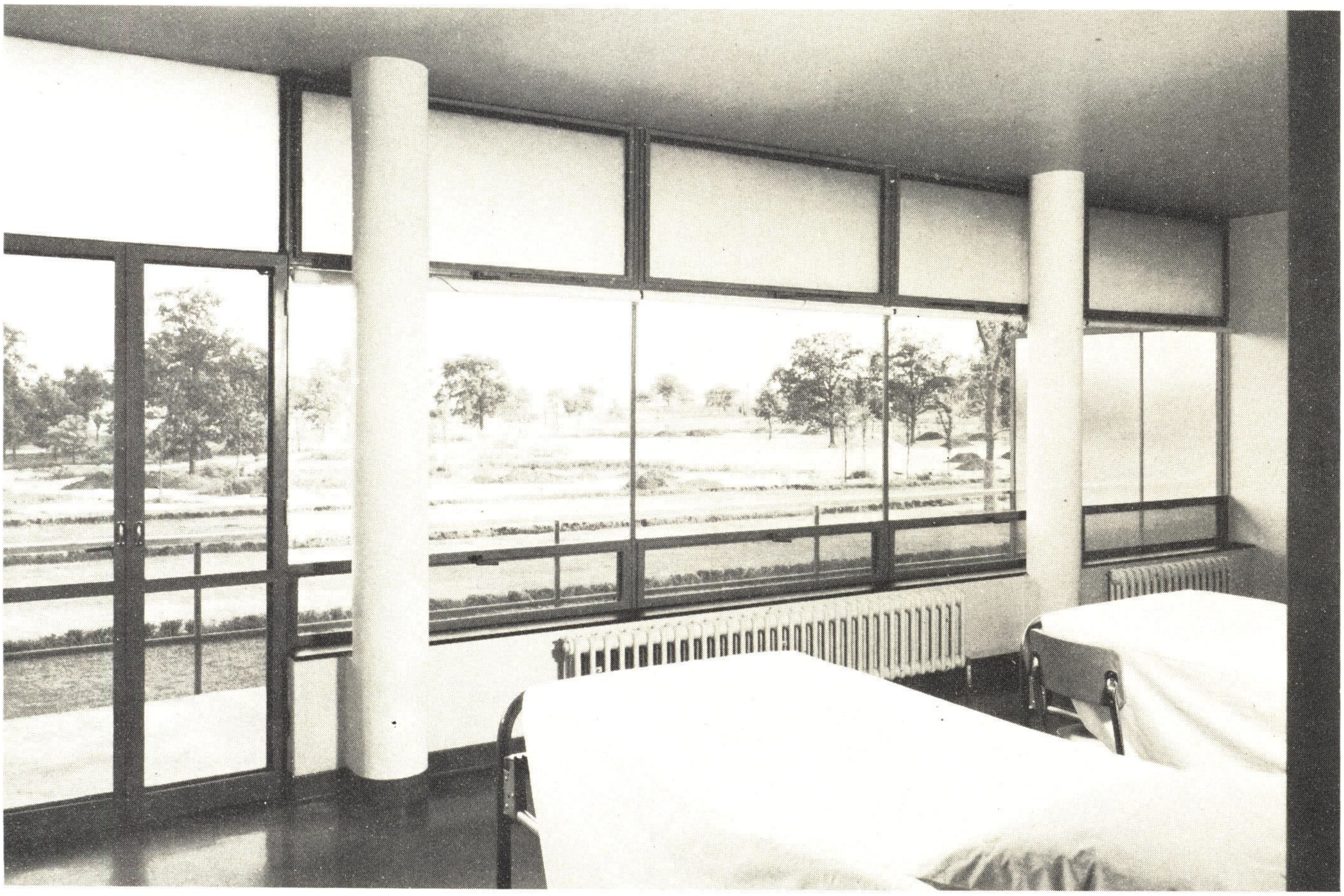
Lake County Tuberculosis Sanitorium. *Architects:* William A. Ganster & Offices of W. L. Pereira. *Location:* Waukegan, Illinois.



SOUTH FRONT

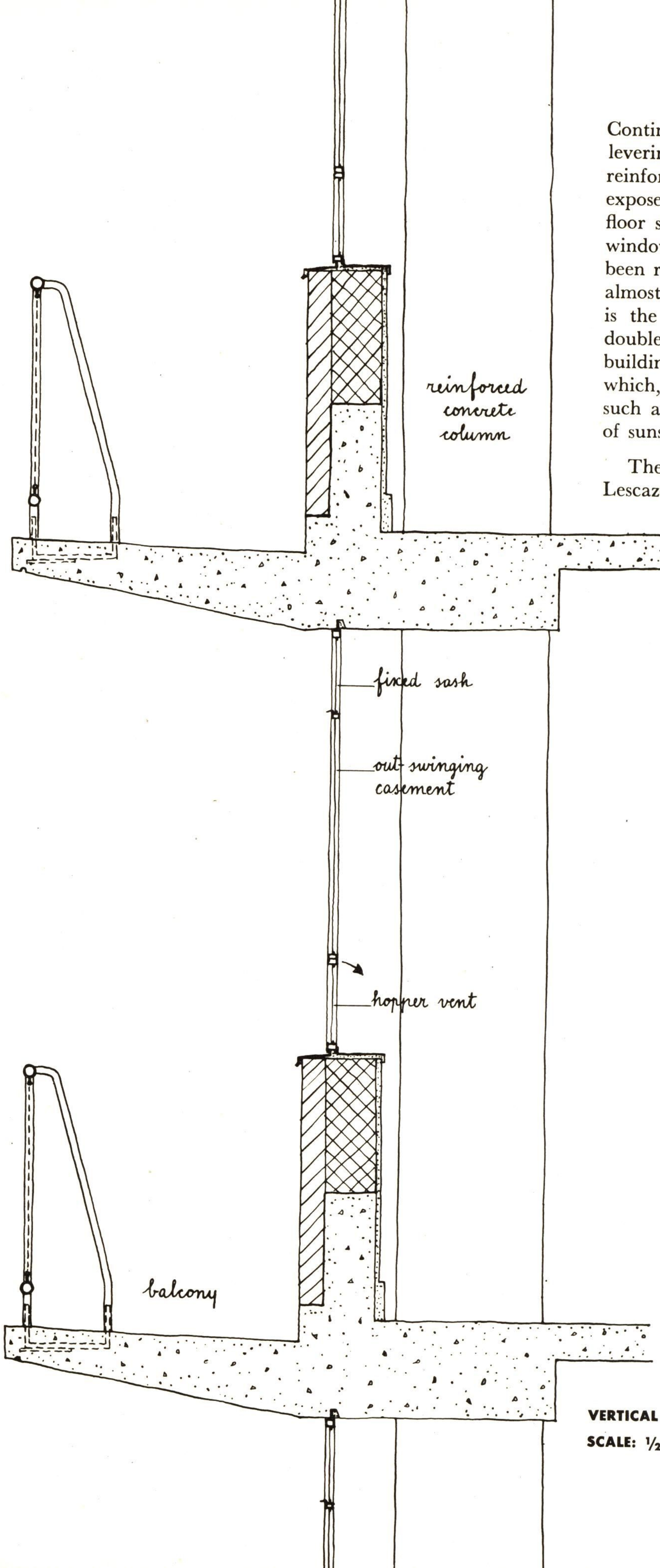


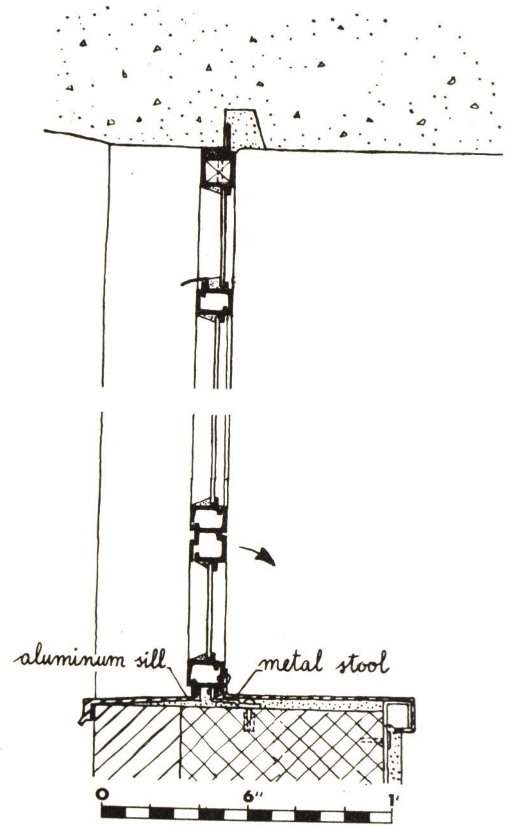
GLASS DOORS IN EACH ROOM *(BELOW)* OPEN ON THE SUN BALCONY *(RIGHT)* DIRECTLY OUTSIDE, WHICH IS COMPARTMENTED BY TRANSLUCENT GLASS SCREENS



Continuous window bands are achieved by cantilevering the face of the building out from the reinforced concrete frame. The columns are left exposed inside. By turning the reinforced concrete floor slab up to form part of the wall below the window band, the depth of the spandrel beam has been reduced, so that the windows can be carried almost to the ceiling line. Another unusual feature is the use of casement windows instead of the double-hung usually considered standard for office buildings. The balconies on the main street front, which, by their texture in depth, give the building such a decided character, also give some measure of sunshading to this south-west front.

The Longfellow Building. *Architect:* William Lescaze. *Location:* Washington, D. C.





SCALE: 1½"=1'-0"

WINDOW DETAILS OF SOUTH-WEST FRONT

VERTICAL SECTION THROUGH SOUTH-WEST FRONT

SCALE: ½" = 1' - 0"

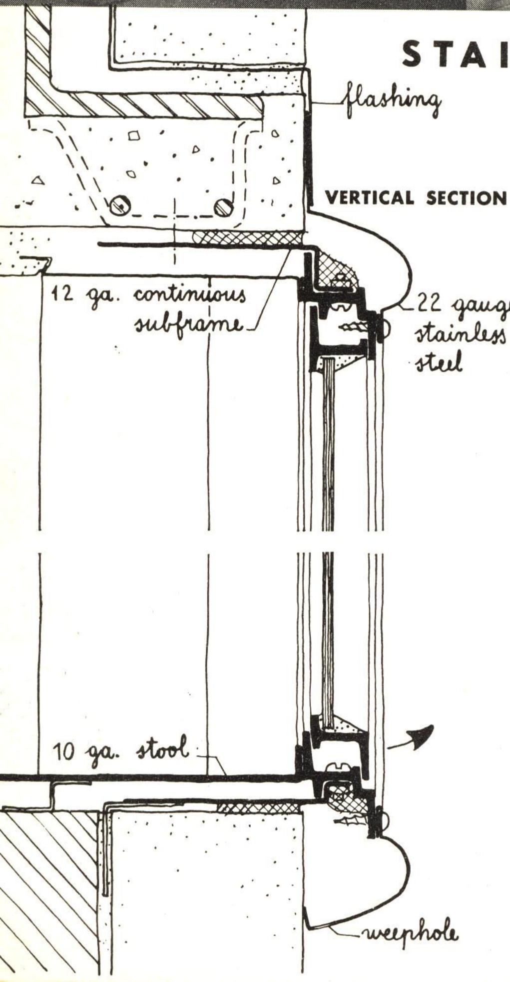
OFFICE BUILDING WITH CONTINUOUS WINDOWS, SUNSHADE BALCONIES

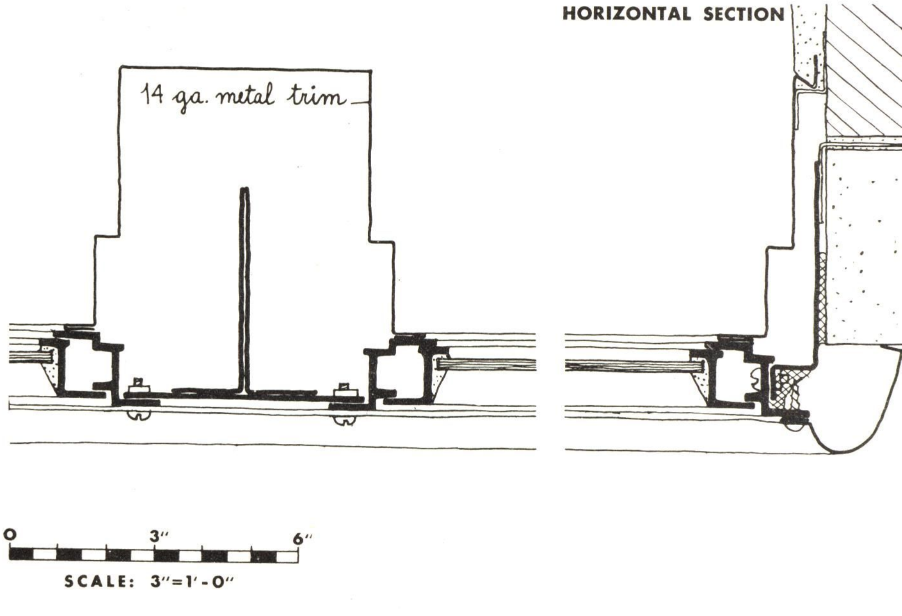
SOUTH-WEST FRONT
ON CONNECTICUT AVENUE

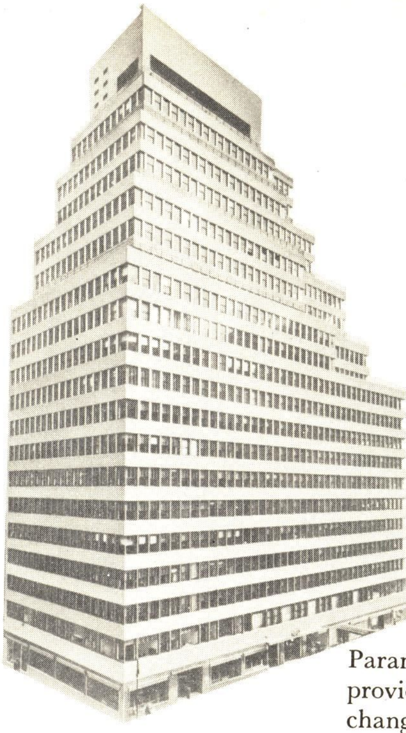
Installation details of these windows are similar to those already proved successful by the same architects in construction of the Empire State Building. Each group of windows is set into a prepared opening flush with the exterior face of the building. That awkward joint between the window frame and the facing material of the building (in this case limestone) is then covered by a stainless steel molding, which also provides a smart frame for the window group. No longer need time be spent finishing the window-to-building-face joint. It need be made weathertight only. All irregularities will be covered by the stainless steel molding.

Hunter College of the City of New York. *Architects:* Shreve, Lamb & Harmon; Harrison & Fouilhoux, Assoc.

STAINLESS STEEL COVERS JOINT BETWEEN WINDOW AND STONE FACING



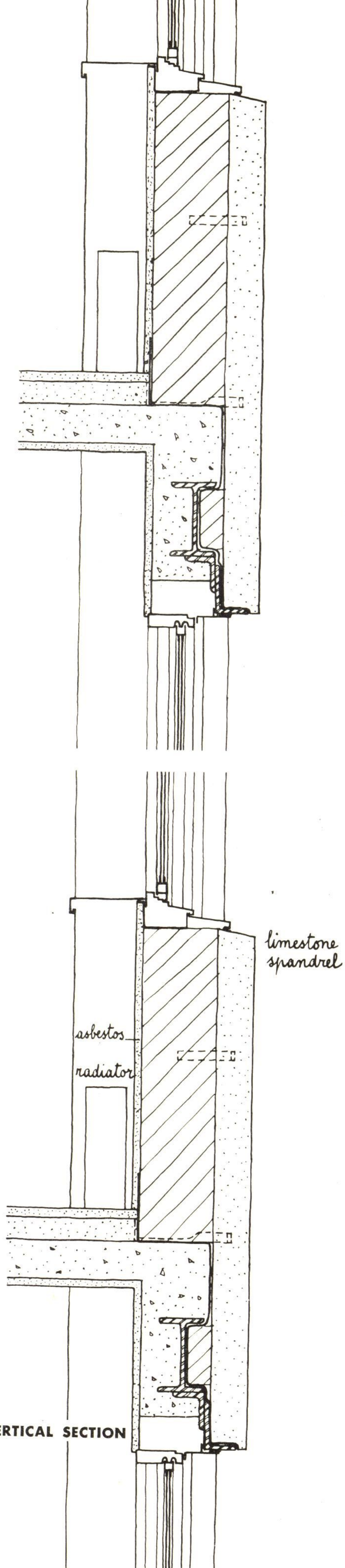




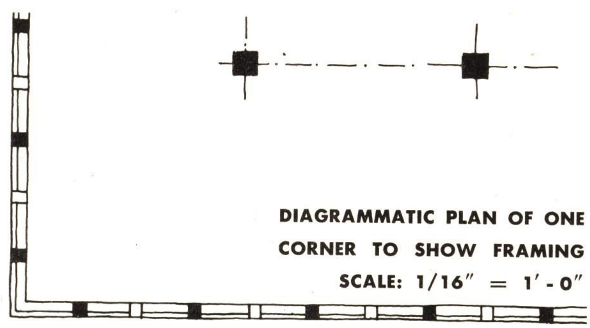
ADAPTABLE FENESTRATION FOR OFFICE BUILDINGS

Paramount need in the modern office building is to provide for offices of various sizes and frequently changing sizes, particularly in the desirable space next to the windows. Here the framing columns along the exterior walls have been made more numerous, and hence smaller, than those in the core of the building. They are spaced 9 ft. 8 ins. c-c.; but to allow partitions along any line of a 4 ft. 10 in. grid, intermediate mullions, of equal width, housing the heating supply and return pipes, are set half-way between each pair of structural mullions: a neat-looking compromise between appearance and reality. All mullions have uniform stainless steel covers with an accordion crimp design to take up irregularities. The windows are installed in pre-assembled pairs, a fixed sash and double-hung in each.

The Tishman Building. *Architects:* Kahn & Jacobs. *Location:* Park Avenue, New York City.

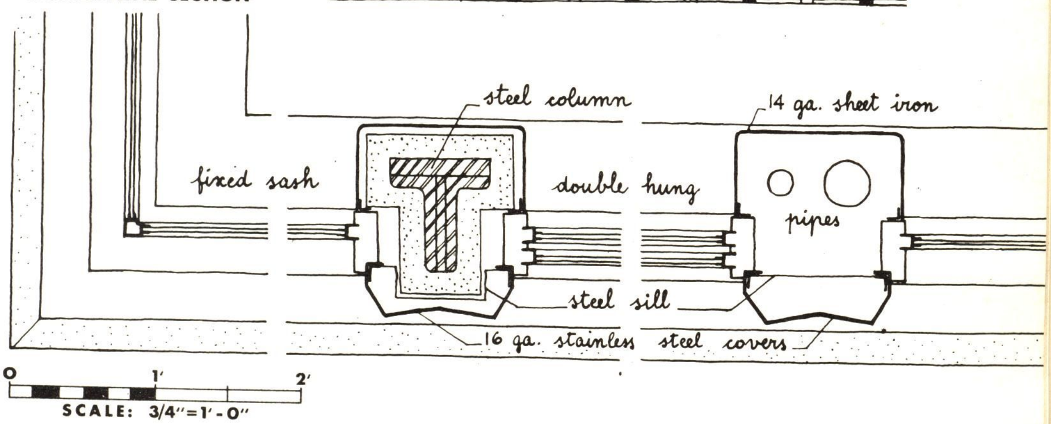


VERTICAL SECTION

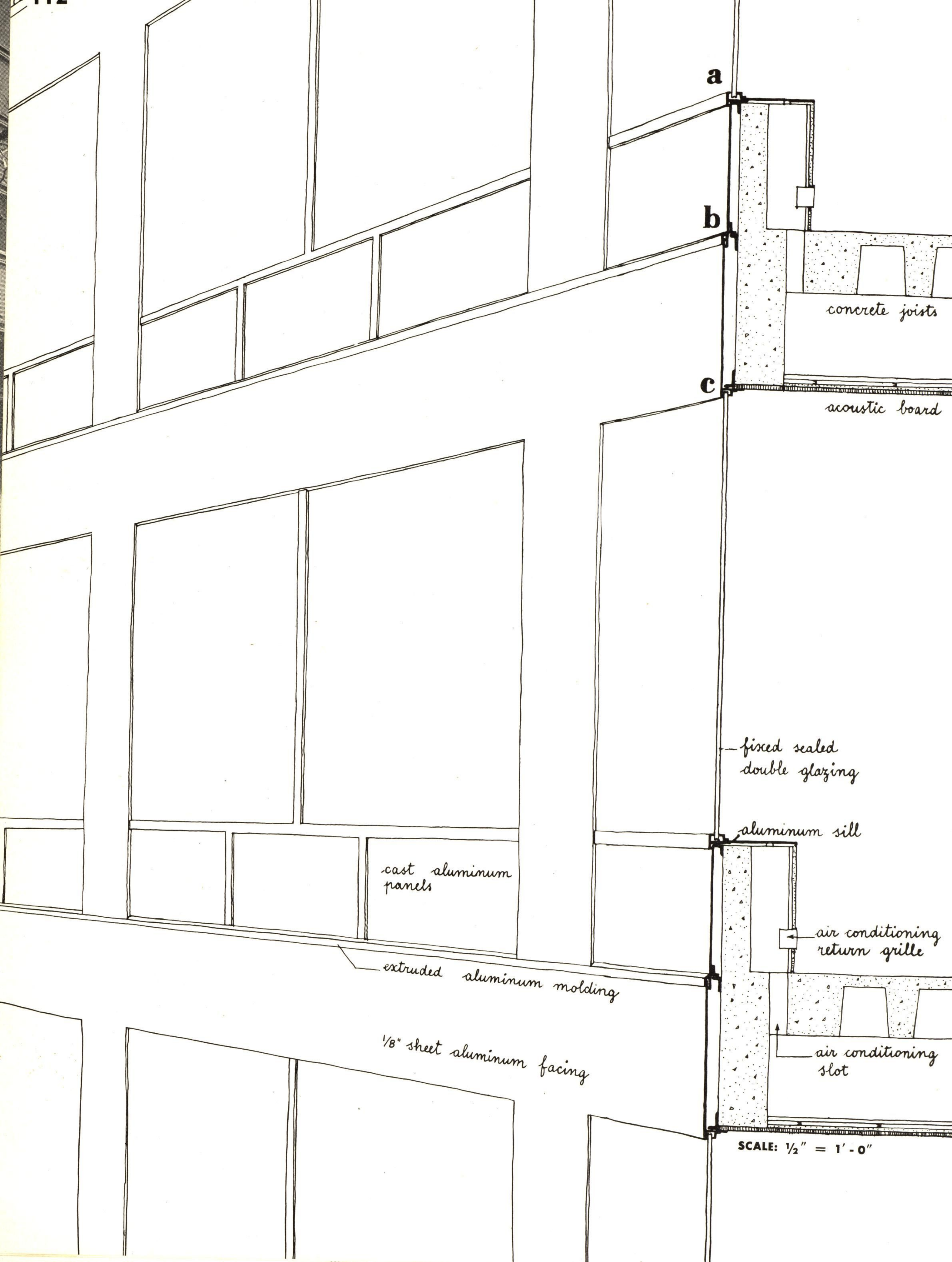


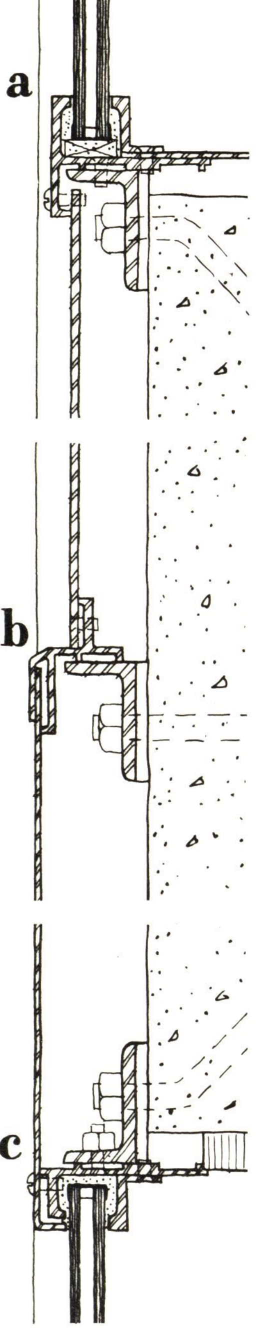
DIAGRAMMATIC PLAN OF ONE CORNER TO SHOW FRAMING
SCALE: 1/16" = 1'-0"

HORIZONTAL SECTION

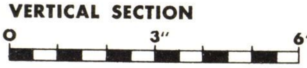


SCALE: 3/4"=1'-0"


a
b
c
concrete joists
acoustic board
fixed sealed double glazing
aluminum sill
cast aluminum panels
air conditioning return grille
extruded aluminum molding
1/8" sheet aluminum facing
air conditioning slot
SCALE: 1/2" = 1' - 0"

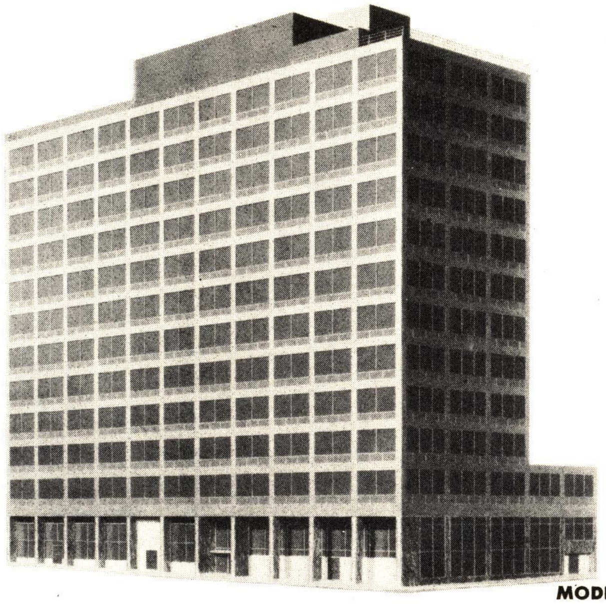


VERTICAL SECTION

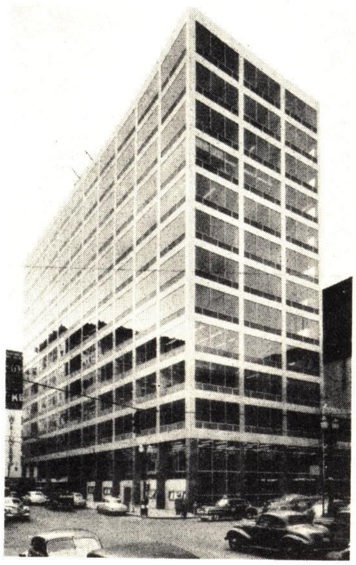


SCALE: 3"=1'-0"

HERMETICALLY SEALED BUILDING



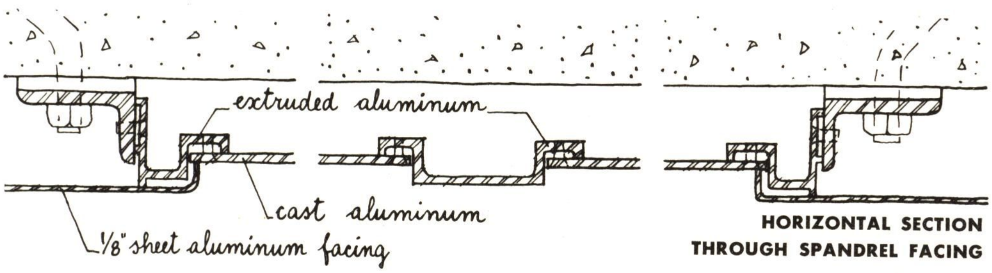
MODEL



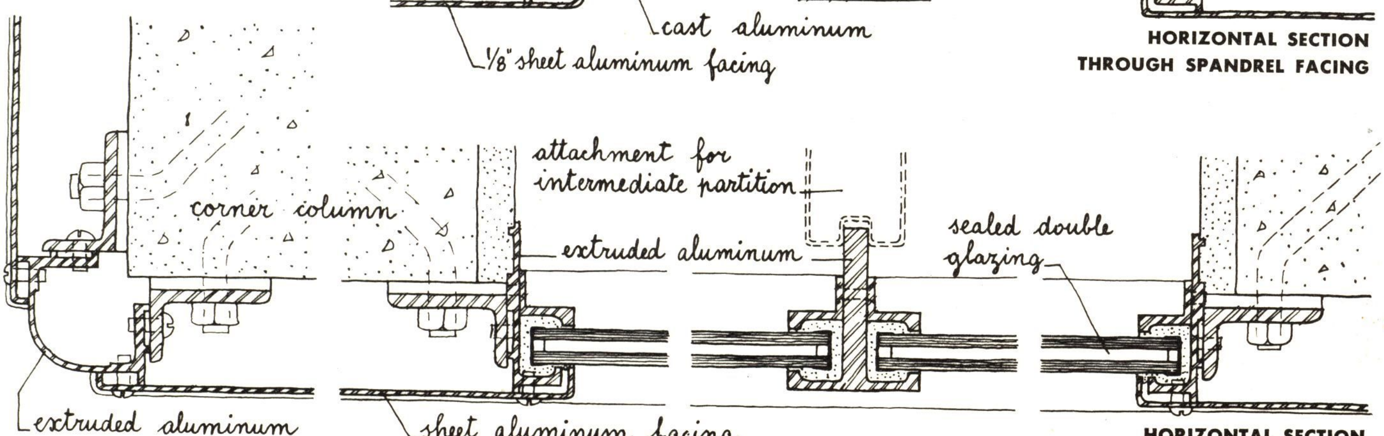
COMPLETED BUILDING

This office building is completely air-conditioned with an electrically-powered reverse cycle system of heating and cooling. This was rendered economic by the low cost of hydro-electric power in Oregon, and the use of fixed sealed double glazing in all window openings. There are no windows in the conventional sense. The glass is used as a transparent walling sheet held by extruded aluminum moldings. These also hold the aluminum sheets which cover the reinforced concrete frame of the building. This frame is acknowledged and made visible throughout. The difference between the face of the spandrel beam and the sill wall above is marked by a change from sheet aluminum to panels of cast aluminum. This building is a significant example of a modern trend away from masonry facing and opening sash.

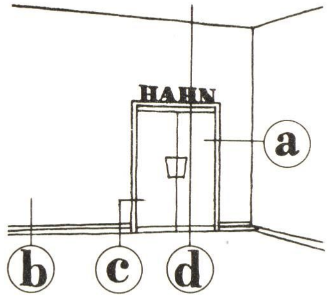
Architect: Pietro Belluschi. *Location:* Portland, Oregon. *Owners:* Equitable Savings & Loan Assoc.

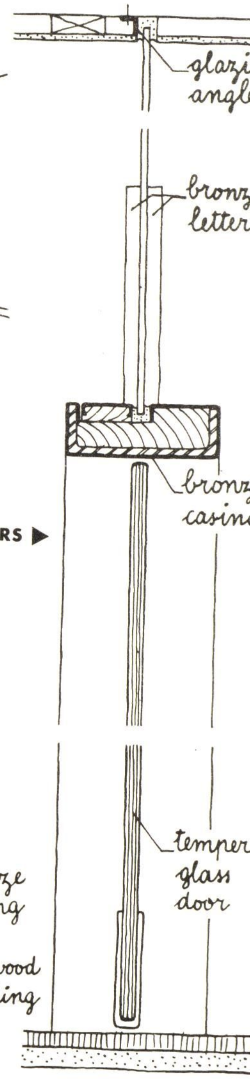


HORIZONTAL SECTION THROUGH SPANDREL FACING

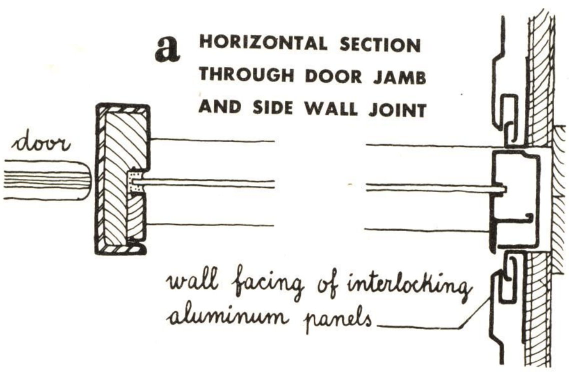


HORIZONTAL SECTION THROUGH WINDOW STRIP

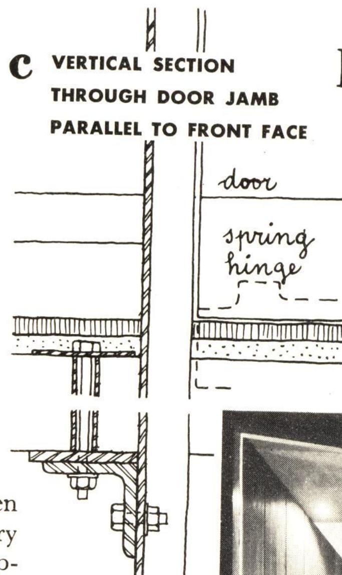




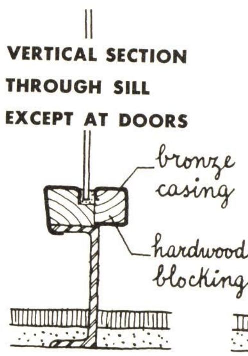
d VERTICAL SECTION AT ENTRANCE DOORS ▶



a HORIZONTAL SECTION THROUGH DOOR JAMB AND SIDE WALL JOINT



c VERTICAL SECTION THROUGH DOOR JAMB PARALLEL TO FRONT FACE

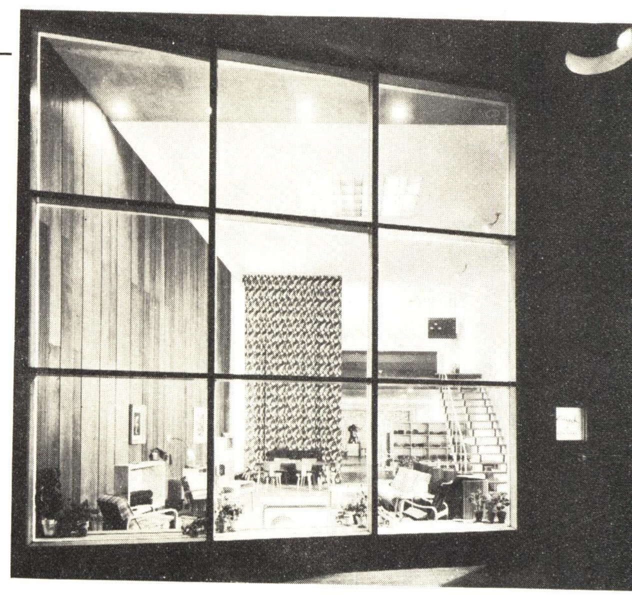


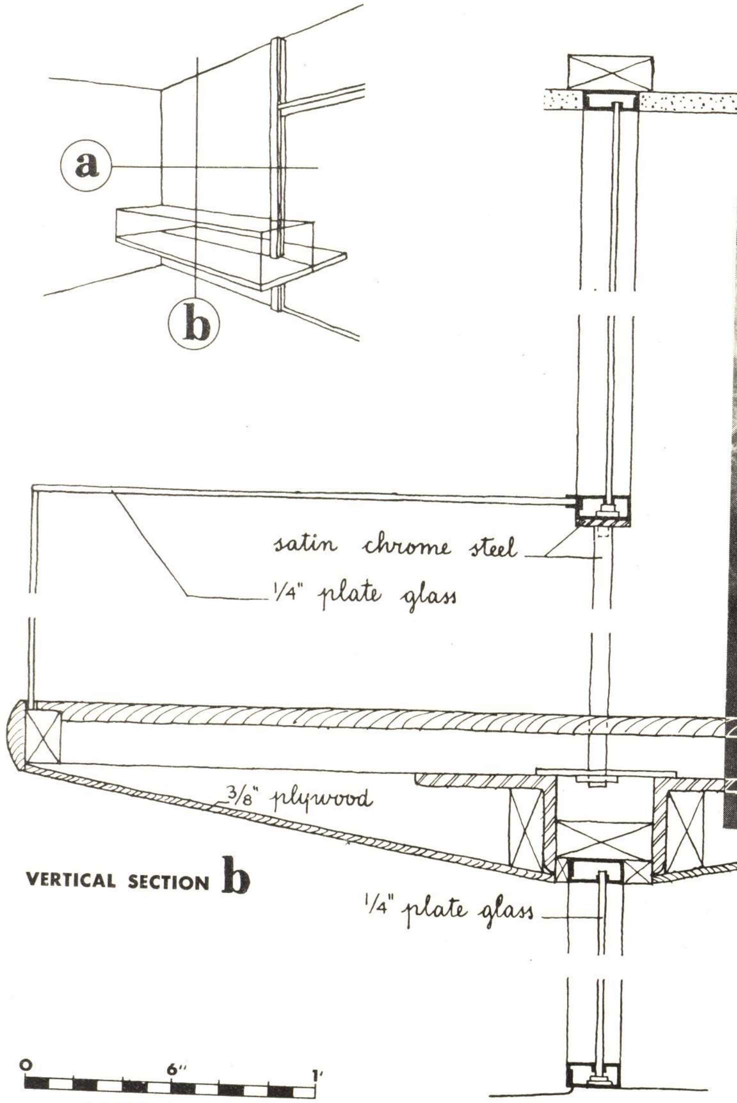
b VERTICAL SECTION THROUGH SILL EXCEPT AT DOORS

STORE WINDOWS

Typical of the smaller modern store is an open front. An entrance arcade — ranging from very large (above) to a vestigial remnant (right) is separated from the interior of the store by a glass screen wall. The framing of this glass is usually buried, so that walls and ceiling may appear to continue through uninterrupted from the street to the inner part of the store. The store at lower right, originally designed for Artek-Pascoe, furniture dealers, is interesting for its use of wood in a field where metal is nowadays normal practice.

Architects: (above and lower right) Ketchum, Giná & Sharp; (upper right) Carson & Lundin and W. L. Murray. *Locations:* (above) Washington, D. C.; (lower right) New York City; (upper right) Harrisburg, Pa.

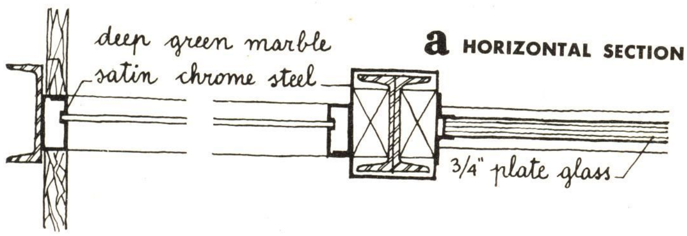




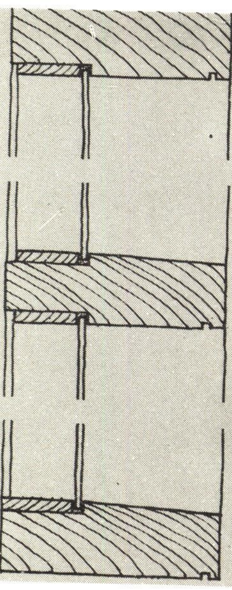
VERTICAL SECTION **b**

SCALE: 1½"=1'-0"

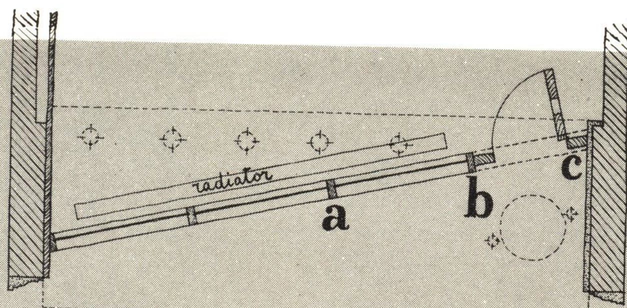
a HORIZONTAL SECTION



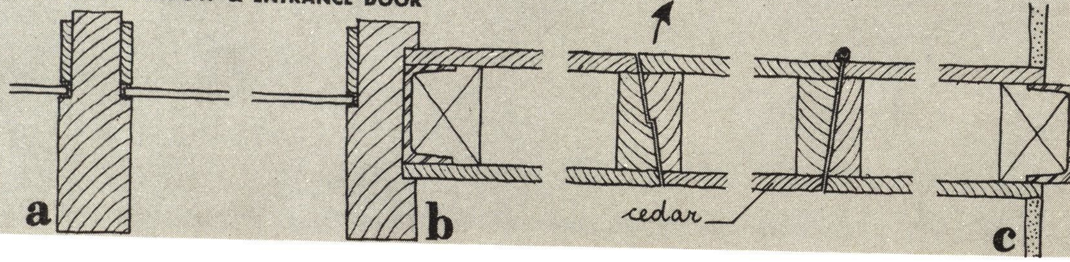
VERTICAL SECTION THROUGH WINDOW



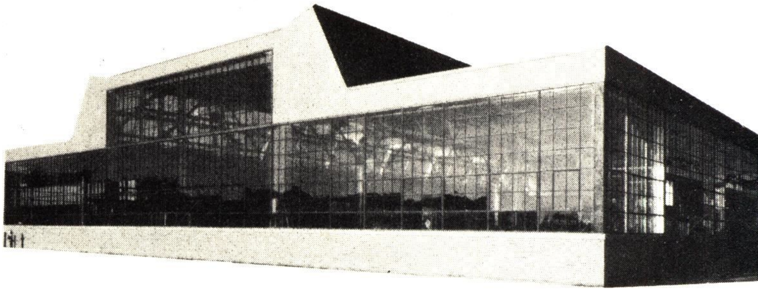
PLAN OF STREET FRONT



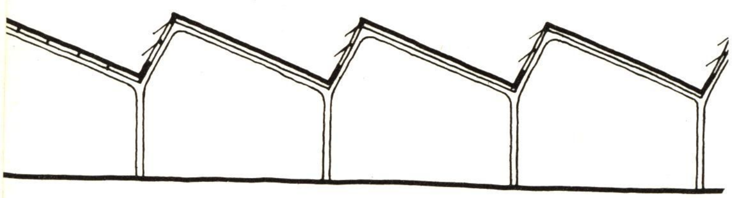
HORIZONTAL SECTION THROUGH WINDOW & ENTRANCE DOOR



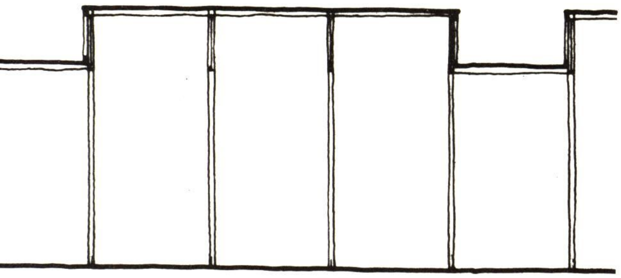
WINDOWS FOR INDUSTRIAL PLANTS



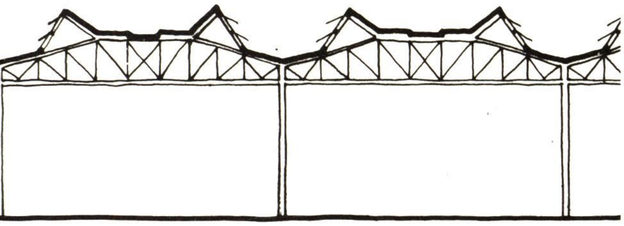
Best current examples of prefabricated window walls are in modern industrial plants (we are not concerned here with the completely closed buildings essential for some processes). Stock metal window units (see page 43), with opening sash and fixed vents placed as needed, are bolted to each other and attached by angle plates to the building frame (see page 121). But, given such a vast floor area, window walls alone, though on all four walls, could not throw daylight sufficiently far into the interior to give that shadowless, high-level illumination which is required. Good ventilation and ease of cleaning are also essential. So the designer has recourse to all sorts of monitors, skylights, and sawtooth roofs. For good illumination without sun heat these usually face east and west, north lighting being reserved for those conditions where two-sided lighting is less important than even-quality light. On this and the following two pages are illustrated a few of the more interesting types of roof lighting.

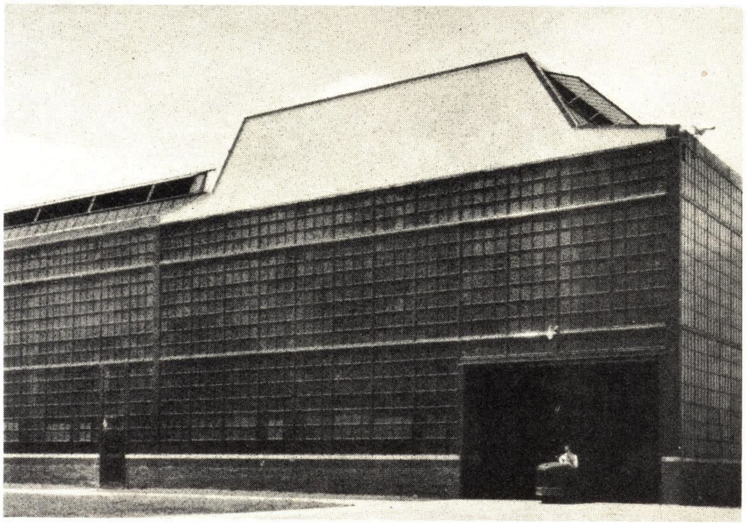


North light—sunlight reflected from the clouds—is the most even and constant daylight available. It is the only satisfactory type in any manufacturing process where color comparisons are necessary. But it is one-sided; to combine it with south lighting would introduce very troublesome sun heat. The photo is of a north-light plant with a welded steel frame which eliminates all shadow-casting trusses. The aisles are 40 ft. wide. The Austin Co.

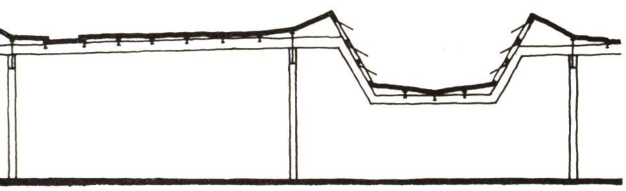


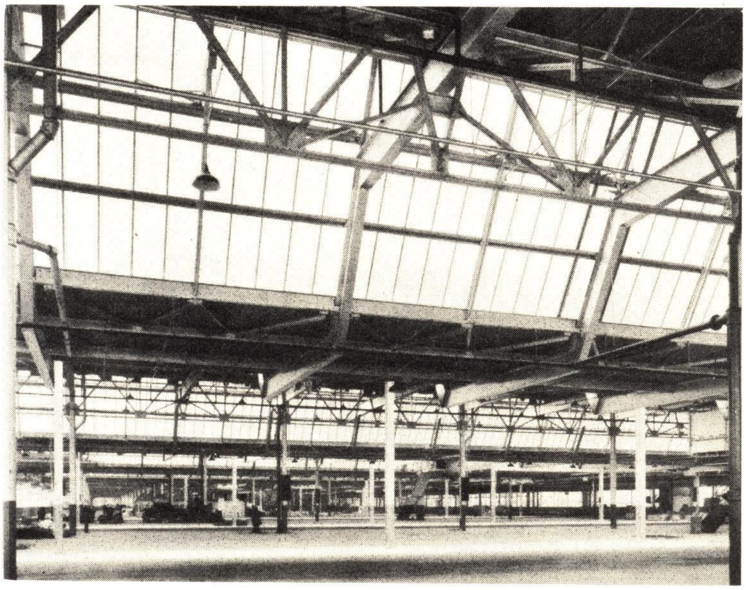
Monitor lighting is shown here dressed up for use in a drafting room. Glass block is used instead of clear glass, for better light distribution. The metal frame has been covered with plaster, and a hung ceiling of acoustic tile added. Fluorescent lights are automatically controlled. Austin Co.



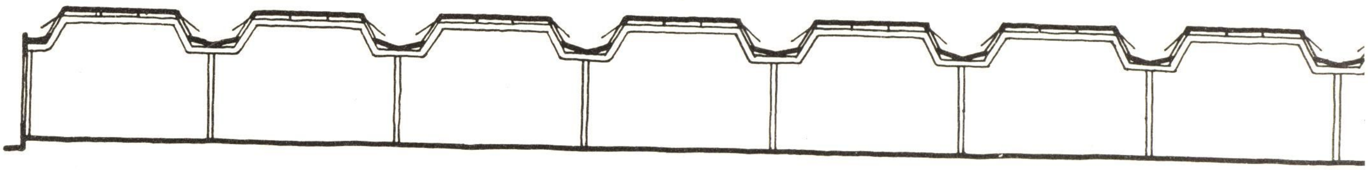


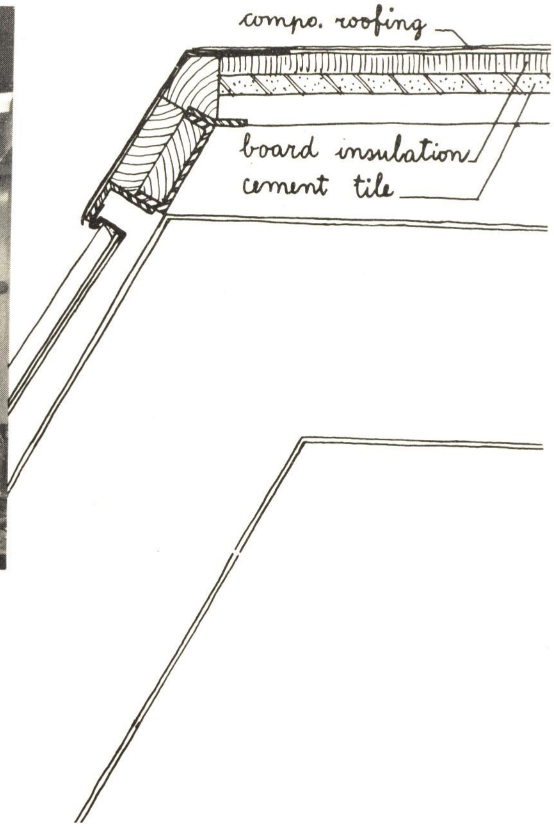
These windows are kited up above the line of the trusses, to give more light and catch more ventilating breezes. Continuous windows will give much more weatherproof ventilation this way than they would if set almost horizontal. Albert Kahn Associated Architects & Engineers.

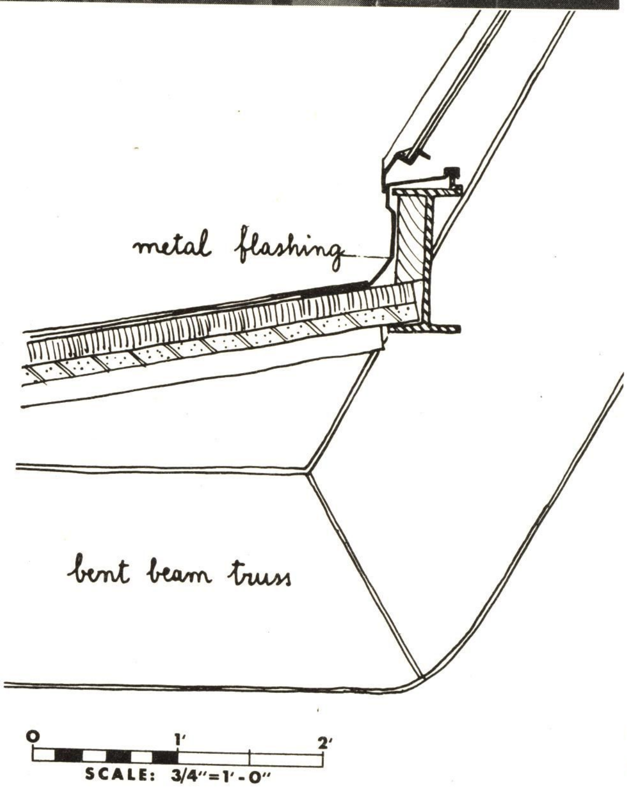




Here the monitors are hung below the roof instead of being projected above it. By thus "building the roof upside down" shadowless daylight is brought right into the working area throughout the plant. The experience of the designers might usefully be applied to the daylighting of other types of one-story buildings. Albert Kahn Assoc. Arch. & Engs.







DAYLIGHT TROUGHS

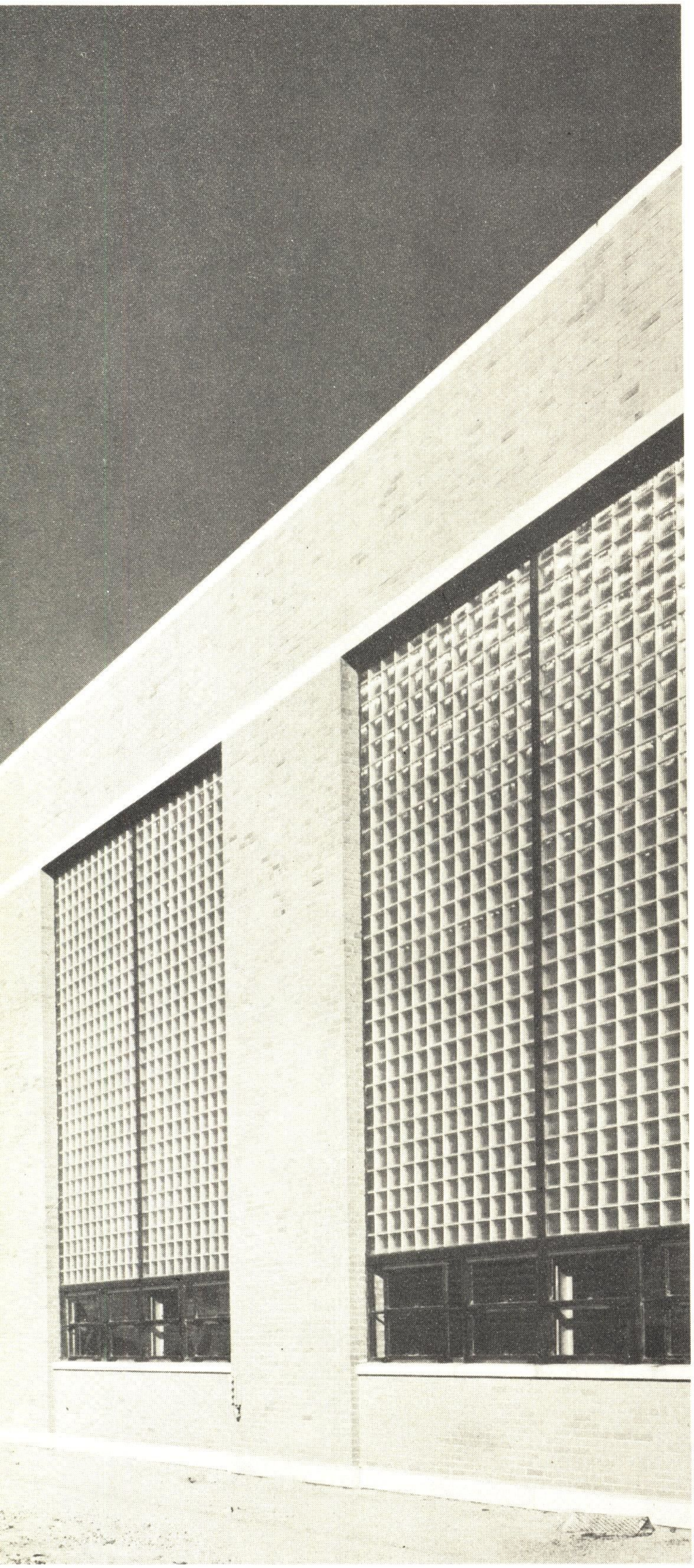
These bent-beam trusses are a less exaggerated version of the upside-down monitor shown on the previous page. The daylight troughs, combined with a cross grid of fluorescent lamps, give exceptionally even, shadowless light for precision work.

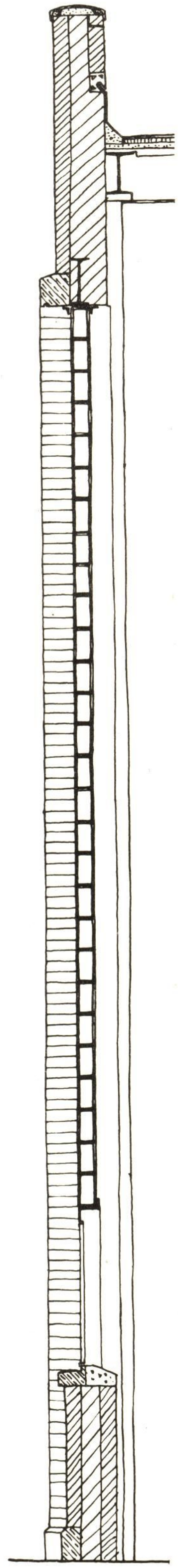
Architects and Engineers: Albert Kahn Assoc. *Location:* Chicago, Ill. *Owners:* Amertorp Corp.

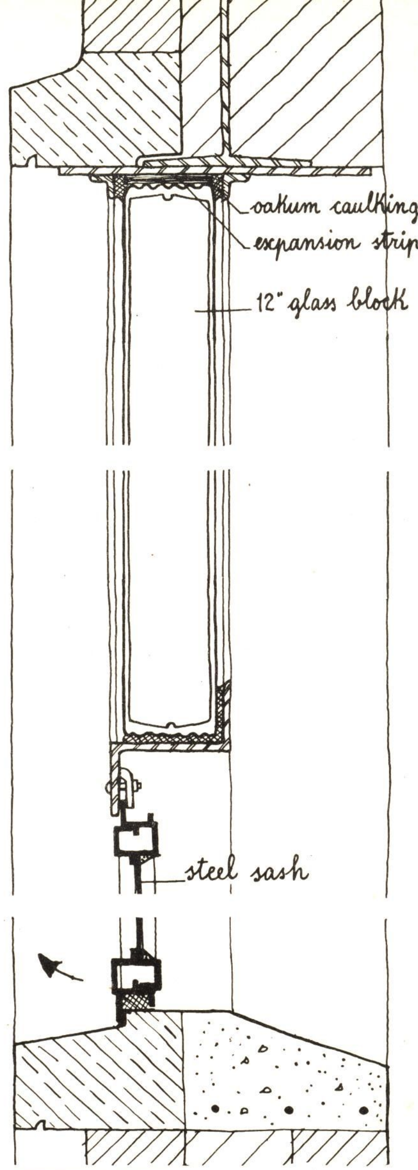
DIFFUSED DAYLIGHT ▶

Glass block gives better light diffusion than the standard industrial window wall (shown on page 121), but is more expensive. It also cuts heat loss in winter, sun heat gain in summer. The clear glass strip ventilates, prevents a boxed-in feeling.

Shops for Rock Island Railroad. *Architects:* De Leuw Cather & Co. *Location:* Chicago, Illinois.





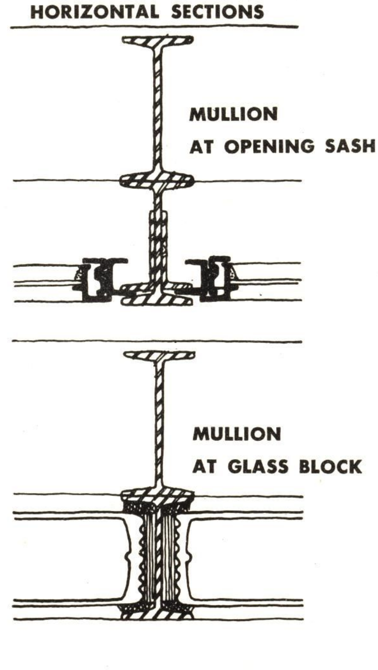


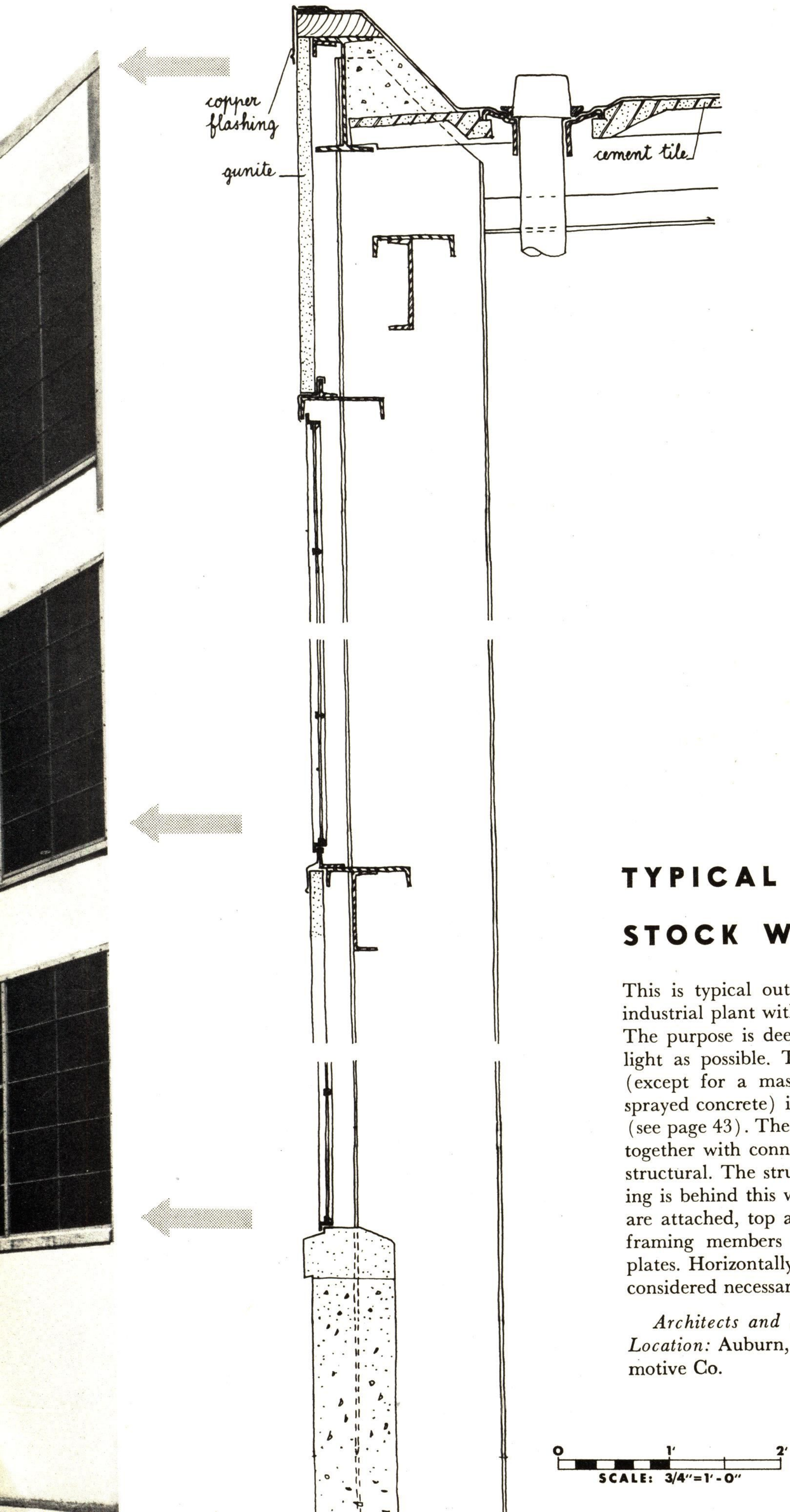
VERTICAL SECTION

0 6" 1'

SCALE: 1½"=1'-0"

HORIZONTAL SECTIONS





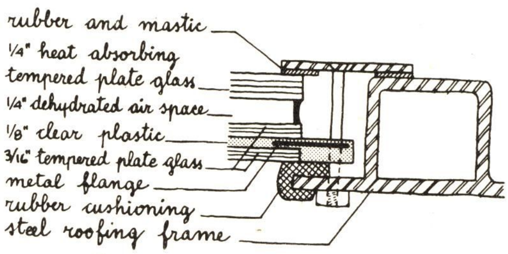
TYPICAL INDUSTRIAL STOCK WINDOW WALLS

This is typical outside wall construction for any industrial plant without specialized building needs. The purpose is deep penetration of as much daylight as possible. The whole surface of this wall (except for a masonry base and three strips of sprayed concrete) is made up from stock steel sash (see page 43). These prefabricated units are bolted together with connecting mullions which are nonstructural. The structural steel frame of the building is behind this window wall. The window units are attached, top and bottom only, to the vertical framing members by means of projecting angle plates. Horizontally pivoted vents are set wherever considered necessary for ventilation.

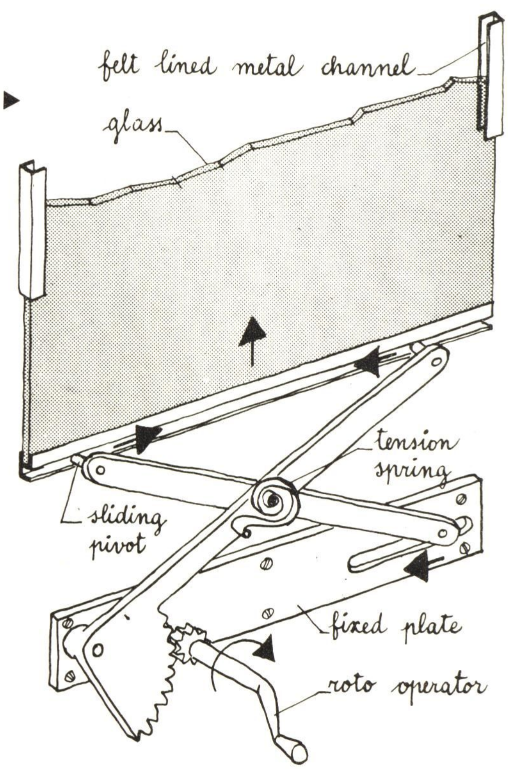
Architects and Engineers: Albert Kahn Assoc. *Location:* Auburn, N. Y. *Owners:* American Locomotive Co.

SPECIAL WINDOWS FOR TRANSPORTATION

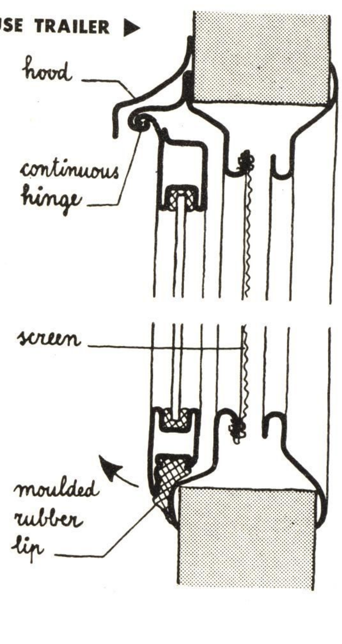
Windows for automobiles, trains and airplanes are designed for a harder but shorter life than those of a house. Glass laminated with clear plastic is used for strength and safety. The rubber sealing strip between glass and frame can be quickly applied on a mass-production assembly line. For blocking off sun heat, heat-resisting glass is used in the sealed double glazing of two-level, top-lit coaches such as the Burlington's Vista Dome (top) and General Motors' Astradome (photo and window detail below). For adjustable shading there are few devices as good as the Polaroid double window (bottom left), but its cost will continue to put it beyond the means of most building owners. More pregnant with unexploited possibilities is the standard automobile window (bottom right): unframed glass sliding in a felt-lined metal channel.



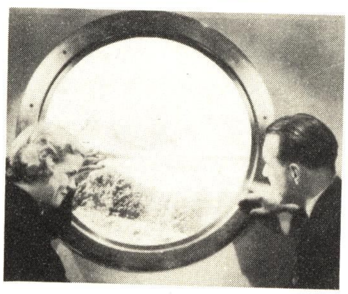
AUTOMOBILE WINDOW OPERATOR ▶
SCISSOR ARM TYPE



TOP-HUNG WINDOW FOR HOUSE TRAILER ▶



TURNING ONE OF THE TWO POLAROID-GLASS SHEETS IN THIS WINDOW (*BELOW*) WILL GIVE ANY DEGREE OF LIGHT OR SHADE. A TRULY INTEGRAL BLIND



GLASS : PROPERTIES AND TYPES

Glass remains today, as it has for hundreds of years past, the best available material for transparent and translucent walls. Transparent plastic sheet, its only recent rival, has the advantages of being lighter in weight, more flexible, more easily shaped, less brittle, more easily worked. All these features make it particularly attractive to the aircraft constructor. Buckminster Fuller used it for the lightweight, curved window strip in his abortive Dymaxion house. But so far building designers have not generally considered the special qualities of transparent plastic sheet to outweigh its disadvantages, particularly its high cost (compared with glass), its softness (which allows it to be easily marred and bent out of shape), and its so far unproved ability to stand up to the severe and continuous weathering to which an exterior walling material is subjected. Moreover the technicians of the glass industry have gradually succeeded in eliminating—or at least minimizing—some of the innate defects of glass as a building material.

It is no more than a century since the only available window glass was expensive, brittle, in small sheets, and so wavy and irregular in texture that vision was badly distorted. These limitations, plus the fact that glass was very expensive before modern mechanical production methods were perfected, were responsible for the small-paned sash which is still with us today, although the mechanical limitations of glass have long since been eliminated. Now polished plate glass, its parallel faces giving undistorted vision, can be made sufficiently strong and in large enough sheets to give floor-to-ceiling glass walls unbroken by muntins. Standard sizes of glass now far exceed the conventional 8 by 4 feet wallboard limits.

While the coefficient of expansion of glass is less than that of most metals, it is greater than that of stone or wood, the materials with which it is usually associated in building. Even when specially tempered for strength a large, and economically thin, sheet of glass used as a window wall is still comparatively brittle. With the advent of large-scale use of glass in building, there has been developed a skilled profession and special equipment. Just as a carpenter and special tools are necessary for woodworking, so is a glazier and his equipment needed on most buildings today. Certain types of glass, particularly tempered glass, must be factory-finished. All work must be done on tempered glass before tempering; trying to cut or drill the finished product may cause it to disintegrate.

It is always necessary to frame a glass wall or panels in wood or metal, rather than attempt to connect the unframed glass sheet directly to the building with wood or nails. It is also advisable to protect the material still further by interposing some soft cushion, such as mastic, felt, rubber or putty between the glass and its building frame, in order to isolate the glass from the stress and movement which most buildings suffer.

The strength of glass is not exactly predictable, even with the carefully controlled methods of manufacture now in use. Strength has been found to vary widely from one sheet to another of the same size and type. When comparing the strength of sheets of different thicknesses a good general rule is that the strength will vary approximately as the square of the thickness.

Glass is much stronger (8 to 10 times) in compression than in tension. As its strength depends primarily on surface tension, sheet glass, with its original, fire-finished surface, is at least twice as strong as polished plate (where the original surface has been ground away; see page 124) of the same size and thickness. For the same reason it is only necessary to cut through the surface skin of a sheet of glass for the whole thickness of the sheet to be easily and exactly broken along this line.

Under sustained loading the strength of any glass sheet can be safely considered no more than half that of the same glass under intermittent stress. Wired glass, contrary to some popular impressions, is always weaker than ordinary rolled glass of comparable thickness; but it does hold together and not disintegrate when cracked, which explains its use as a hindrance to fire and thieves. Tempered glass has a modulus of rupture approximately four times greater than that of the same glass untempered, approximately twice that of the same glass semi-tempered.

The basic raw materials of glass are silica, lime, soda and alumina. By altering the relative proportions of these materials and the processes of manufacture, glass of a special type can be "built" by skilled technicians to meet almost any specifications. This accounts for the increasing number of special-purpose glasses now available.

Then the comparatively recent perfection of sealed

glazing—two or three sheets of the same or different type glass interleaved with sealed air spaces, all combined in a single homogeneous sheet—now makes it possible to manufacture a transparent or translucent wall which will more exactly fit a given set of requirements.

Until the development of multiple glazing the typical thin, dense sheet which is glass, had the advantage of its hard, brilliant surface, impervious to weathering and all normal scratches (it is one of the few building materials which require no protective finish); but it also had the concomitant disadvantage of low resistance to heat transmission with the attendant troubles of condensation and excessive heat loss. Now these troubles can be avoided permanently; the heat resistance of a transparent glass wall can be brought up to almost half that of a conventional insulated opaque wall.

Moreover glass has the ability to let in and trap sun heat within the building, for it is transparent to heat rays from a high-temperature (above 500°F.) source like the sun, opaque to the lower-temperature radiation trying to pass in the reverse direction, from the inside of the building outward. Whether this heat gain from the sun through southern windows will offset the heat loss from inside outward (considering both radiant and convected heat) is still under investigation (see page 138).

In the manufacture of glass uniformity and perfection are both difficult to achieve. Even the smallest defect in a transparent sheet stands out prominently. The three grades of polished plate (silvering, mirror glazing, and glazing), and the four grades of sheet glass (AA, A, B, and Greenhouse) indicate no difference in raw material or manufacturing process between one grade and another; they simply provide a measure of the number and type of defects in the finished glass.

The larger the piece of glass the more difficult it becomes to avoid some grade-lowering defect. For the reasons which we have outlined, the price spread between different sizes and qualities of clear class is very wide.

TRANSPARENT GLASS

All transparent sheet glass used today falls into one of two basic categories, sheet or plate. The distinction is one based on manufacturing processes which, in turn, set their characteristic mark upon the finished product.

In the manufacture of sheet glass the molten glass, drawn from the furnace in a congealing ribbon, hardens without its surface being brought into contact with any table or rollers (the sheet is carried upward to a cut-off floor by rollers which grip the edges only). Consequently the finished sheet has a sparkling, uneven surface, which gives very slightly distorted vision even in the least imperfect grade (AA). However, when used in comparatively small pieces, and in single thicknesses, as in traditional window panes, this slight distortion is unobjectionable, but large sheets and double glazing make it show.

Before perfection of the continuous upward-drawn process of manufacture, window glass was flattened blown glass. "Crown" glass (still made today) is cut from a large, almost flat disc formed by squashing a molten, blown-glass sphere end to end, which accounts for the typical curving lines of bubbles and streaks usually found in this glass.

In large unbroken sheets of glass (for example in "picture windows"), and especially for any type of double glazing, polished plate will give much clearer vision than sheet glass. In manufacturing plate glass a rough-rolled sheet is ground and polished until the two faces are as nearly as possible flat and parallel. This is a comparatively lengthy and complex process of manufacture which sends the price of plate up to about five times that of sheet glass of the same dimensions, though special conditions in certain areas of the country lead to many price variations.

By changing the formula of the "frit" (the raw material which goes into the glass furnace to be melted down), and by modification in the process of manufacture, transparent glass can be endowed with a predetermined filter action so that it will allow only certain wave lengths of light to pass. For example, ordinary plate glass is comparatively "blind" to the ultraviolet band of the spectrum, comparatively "open" to the infrared band. Now there is a glass which will allow more of the ultraviolet to come through — for health. There is another which will stop ultraviolet almost entirely—to preserve valuable fabrics, paintings, etc., from fading. In both cases the added cost will probably confine the use of such special glass to hospitals and museums. The ordinary householder will find a sheltered sun terrace and fadeless fabrics serving his needs almost as well.

Heat-absorbing glass will stop most of the infrared radiation, by means of absorption and reflection; and its blue-green or amber color reduces glare (also light). However, half of the heat absorbed will be re-radiated within the building. For really first-rate protection this glass should be used as the outer sheet of a sealed glass sandwich, or else be continually wiped off by a stream of cool air across the inner face.

The special types of glass just mentioned give physical control of daylight. There are others which give what can best be described as psychological control. For example, pink-tinted glass, the modern equivalent of rose-tinted spectacles, might be used to give warmth to a bleak, northerly outlook. Blue-tinted windows would cool off a hot, arid view. And if a completely faithful view is mandatory there is a colorless polished plate free from that greenish cast found in almost every other sort of glass.

All types of transparent glass ¼ in. or more in thickness can now be had in tempered or semi-tempered form, where circumstances justify the added cost of this treatment. Rapid heating of a glass sheet, followed by sudden cooling of its surface, causes this outer layer to solidify while the core is still molten. Consequently, when the core cools the outer layer is in compression, and any forcible defor-

mation of the sheet must be large enough to neutralize this surface compression before any threatening tensile stress can even start to build up.

Such a tempered sheet is between four and five times as strong as an untreated sheet of the same type and thickness. And its thermal endurance (i.e., its resistance to sudden changes of temperature) is increased four times, from a differential of 100° F. to one of 400° F. Semi-tempered sheets have qualities approximately half-way between those of ordinary and tempered sheets. When broken, tempered glass disintegrates into small, regular fragments with relatively smooth edges, quite unlike the jagged fragments of ordinary, untempered glass.

TRANSLUCENT & COMPOSITE GLASS

It has always been much easier to produce a translucent glass than one giving clear, undistorted vision. Today there are three methods in common use for production of glass with a predetermined degree of translucency. In the first, molten glass is impressed with a pattern on one or both faces. This is usually done by passing it through patterned rollers, but in the case of rough, unpolished plate, it is simply run out on to a rough table. The degree of translucency will depend upon the pattern design, which may range from numberless irregular pits 1/64 in. deep, to regular corrugations 1 in. deep and 2½ ins. across.

The second method of producing translucent glass is to roughen the surface of a clear sheet, by sandblasting, grinding, chipping, or etching with acid. Except where grinding or sandblasting is used to make a controlled design, this roughening process gives the glass an all-over "frosting" without definite pattern.

The third method depends upon changing the raw material recipe from which the glass is made. The milky tint of opal glass, for example, which gives it such an excellent quality of light diffusion, is due to the addition of calcium phosphate, which forms minute particles within the body of the glass. Colored glass is achieved in similar fashion, by additions to the "frit". Where opal and colored glass would be too nearly opaque if used in sufficient thicknesses for normal strength, it is common practice to fuse a very thin layer of the special glass to a thicker sheet of clear glass. This process is called flashing. However, all such manipulation is extremely difficult to control exactly; it is almost impossible to obtain an exact color match in two successive batches.

There are other types of composite glass: wired glass, a sheet of wire netting embedded between two sheets of clear glass at their molten stage; safety glass, a sheet of clear plastic between two sheets of clear plate; Thermolux, a diffusing screen of spun glass fibers sandwiched between two sheets of clear glass. This latter combines good light diffusion (it has the effect of a light white cloud before the sun) with some insulating value. By changing the color and composition of the filling, this same principle might yield a whole new range of translucent wall sheets.

A more specialized type of translucent glass, at present too highly priced to be justifiable in any but special uses such as airplanes and trains, is the glass and Polaroid sandwich. A double window formed from two circular sheets of this material, with one sheet which can be revolved, will provide every degree of translucency from a greenish transparency to complete opacity, this latter when the "slats" of the two Polaroid sheets are at right angles to each other (see page 122).

It is only within the last few years that glass technicians have perfected a method of sealing two, three, or even four sheets of glass into a single sheet interleaved with dead air spaces between the sheets. This provides the insulating advantages of double glazing without the inconvenience of separate storm windows. Even more important perhaps, different specialized types of glass can now be combined to give control of heat and light never before feasible in a single sheet. Transparent walls may now be built to fit requirements almost as complex and varied as those already satisfied by the solid wall.

Any translucent glass may be used as a part of such sealed multiple glazing—with a single limitation: the seal will not hold on any but the very shallowest patterns. So most glasses patterned on two sides cannot be used, and those patterned on one side only must have the pattern used on the outside of the sandwich.

GLASS BLOCK

Glass block is a translucent composite glass. It is molded in two halves which are then cemented together, so that two different glass patterns may be combined in a single block, and even a diffusing screen of spun glass fibers set in the middle, thus allowing quite exact control of light.

Like sheet glass, glass block is not a structural material. It is incapable of bearing any but the lightest of loads; it must be set within a frame strong enough to support the weight of the building above, with ample expansion strips and mastic cushions on every side. For quick calculation, it may be assumed that the blocks are available in three sizes: 6 in., 8 in. and 12 in. square, including mortar joints. Openings should be sized in multiples of these measures, though, if necessary, a slight adjustment can be made in overall size by reducing the mortar joints from ¼ inch to not less than 3/16 inch.

When first introduced, glass blocks had a great advantage over sheet glass by reason of their much lower heat transmission. Now their U value of 0.49 is very little better than that of sealed double glazing (0.55 for two ⅛ in. sheets of plate glass with a sealed ½ in. air space between), and not as good as that of sealed triple glazing. However, they still have an assured place as low-cost, tough, translucent walling with good insulation against heat, better than average insulation against sound (transmission loss about 40 decibels).

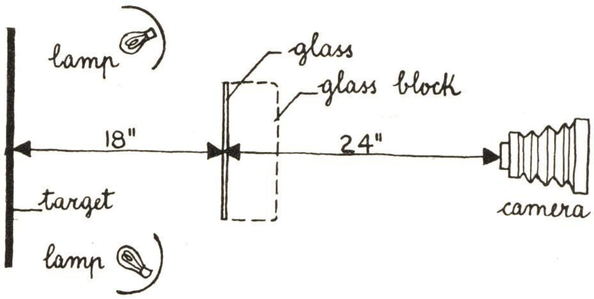
HOW OBSCURE ARE TRANSLUCENT GLASSES AND GLASS BLOCKS?

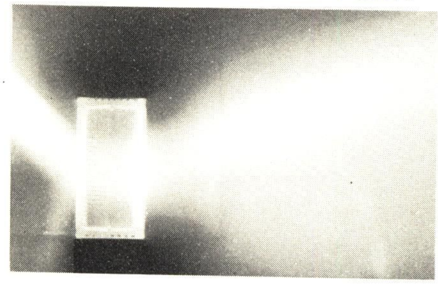
ON THE FOLLOWING THREE PAGES

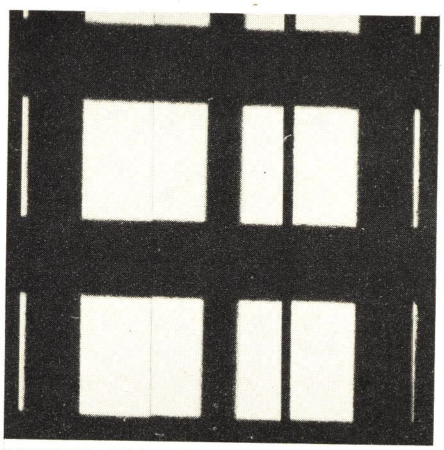
TRANSLUCENT GLASS IN OBSCURITY TEST

Obscurity combined with good light transmission is normally the reason for using translucent glass or glass block on an outside wall. To provide the data necessary for such windows, some representative patterned glasses and glass blocks have been given a standard test (as shown in the diagram below). The results are seen on these three pages. The target was a lattice of black lines 2 ins. wide set 3 ins. apart on a white background. The patterned face of the glass was toward the camera. Figures of light transmission are approximate, and used for comparison only. Actual light transmission in use is much more profoundly affected by dirt than by any glass pattern.

Owens-Illinois LIGHT-DIRECTING GLASS BLOCK, WITH ENCLOSED PRISMS DEFINITELY REDIRECTS THE LIGHT, INSTEAD OF SCATTERING IT ALL WAYS

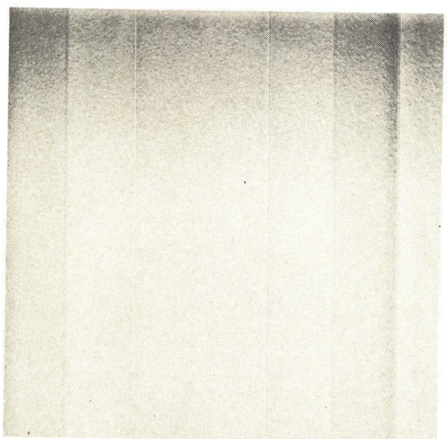




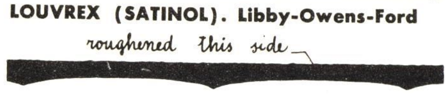


LOUVREX. Libby-Owens-Ford

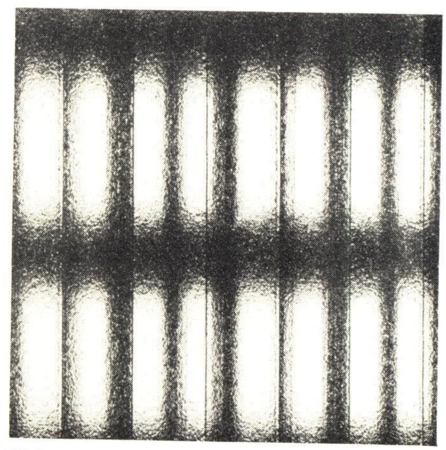
LIGHT TRANSMISSION 90%



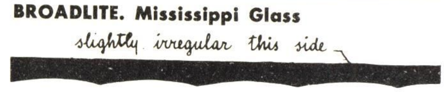
LOUVREX (SATINOL). Libby-Owens-Ford



LIGHT TRANSMISSION 87%



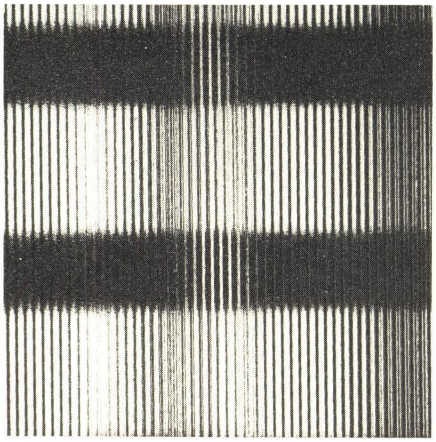
BROADLITE. Mississippi Glass



LIGHT TRANSMISSION 88%

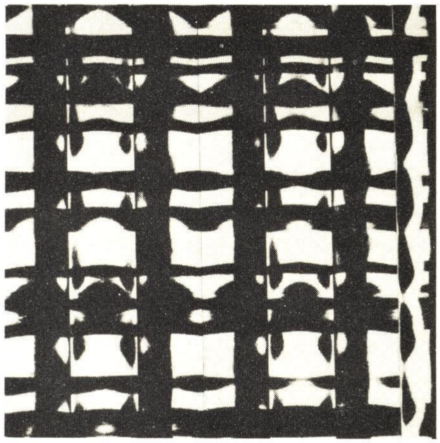
Plain fluted glass will give distortion but not obscurity. The same glass (center) roughened on one side—Satinol finish—becomes completely obscure with a loss of only 3% in light transmission. However, it will mar and pick up dirt more quickly. Better in this last respect, but less obscure, is the fluted pattern (right) with a rough texture rolled into the molten surface during manufacture. For greater obscurity, see the narrow rib patterns (page 127).

PHOTOGRAPHS AND SECTIONS ONE THIRD FULL SIZE



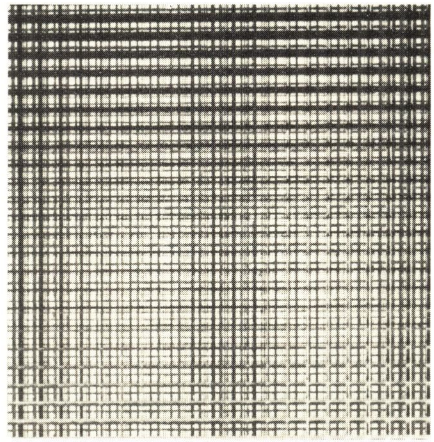
PENTECOR. Mississippi Glass

LIGHT TRANSMISSION 88%

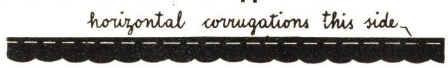


DOUBLEX. Libby-Owens-Ford

LIGHT TRANSMISSION 87%

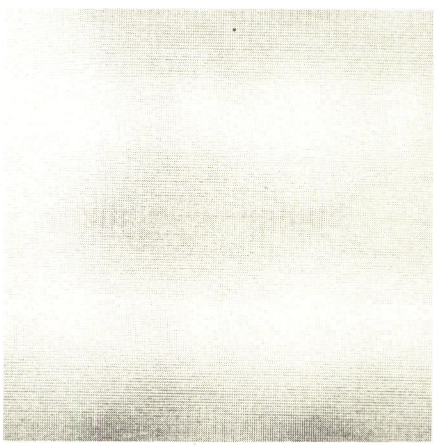


MAGNALITE B. Mississippi Glass

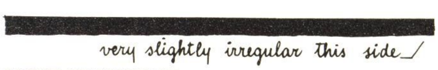


LIGHT TRANSMISSION 80%

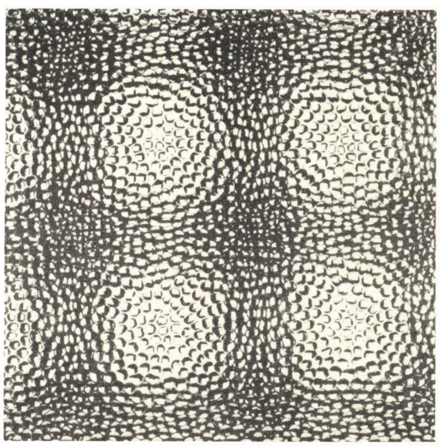
Ribbed glass is basically a form of prism glass diffusing light in one direction only, at right angles to the ribs. Patterning both faces of the glass, with the flutes or ribs on one face set at right angles to those on the other, diffuses light in all directions and over an extended area. When more closely spaced ribs are used the light transmission drops, but the glass retains a characteristic sparkling obscurity which may be used to good decorative effect.



FACTROLITE. Mississippi Glass



LIGHT TRANSMISSION 88%



HAMMERED. Libby-Owens-Ford

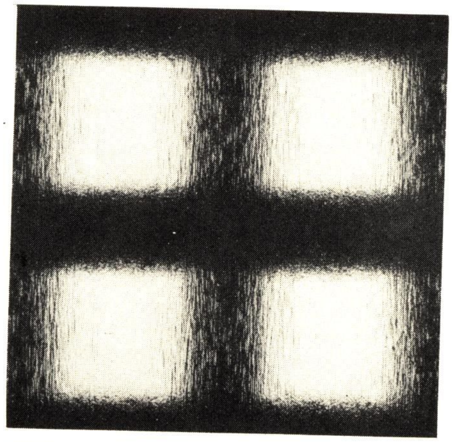
LIGHT TRANSMISSION 89%

SYENITE. Mississippi Glass

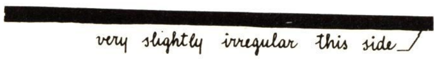
LIGHT TRANSMISSION 87%

What might be called "popply" designs, shallow and all-over, are still the most widely used in factories and offices. And for good reasons: they give excellent obscurity with high light transmission, and they can be quite easily cleaned (most important when considering actual light transmission in normal use). In a commendable search for patterns with more character, the virtues of the old stand-bys, as well as their defects, should be realized.

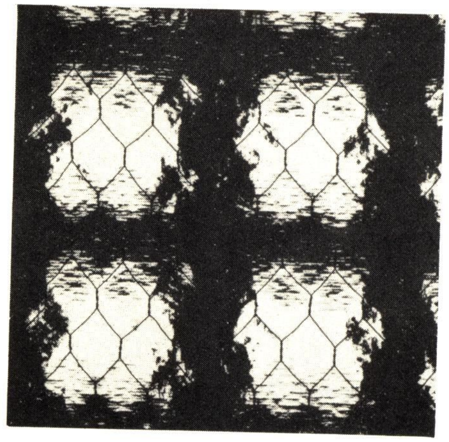
PHOTOGRAPHS AND SECTIONS ONE THIRD FULL SIZE



HYLITE. Mississippi Glass

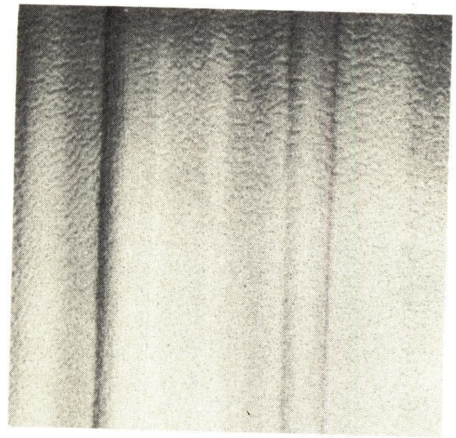


LIGHT TRANSMISSION 90%

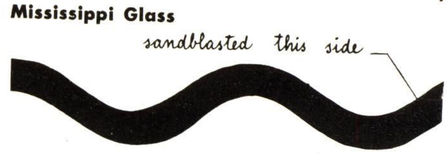


LUMINEX WIRED. Libby-Owens-Ford

LIGHT TRANSMISSION 82%

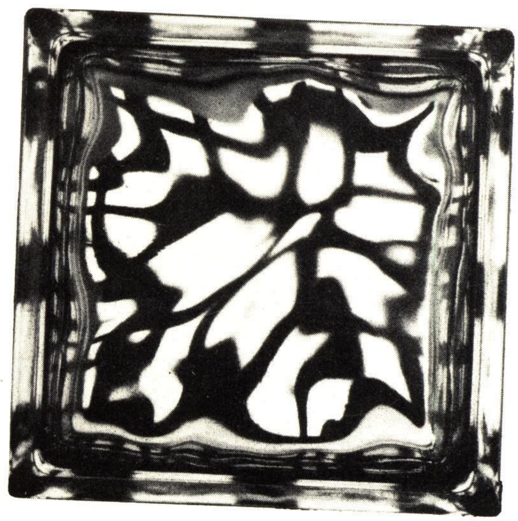


STRUCTURAL CORRUGATED (SANDBLASTED)
Mississippi Glass



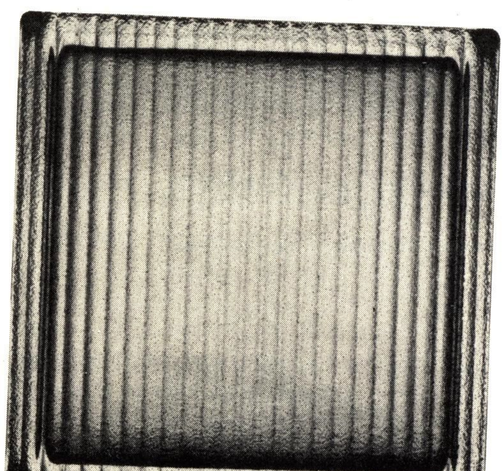
The first two glasses above have very small and shallow patterns so that they have a practically flat surface. The comparatively low light transmission of the wired Luminex is not due to the pattern (light transmission unwired is 88%) but to the wire, whether as shown here or welded.

Glass blocks have several advantages over translucent glass. The clearer types have good light transmission, and a heat resistance above that of sealed double glazing. The figured surfaces can be sealed inside, leaving both outer surfaces flat, easily cleaned. Inside the Decora are gently wavy surfaces, in the Argus the flutes on one interior face are at right angles to those on the other. The Bristol is fluted and sand blasted, and has a glass fiber screen sealed in the center. The result is good heat resistance and light diffusion (obscurity), poor light transmission.

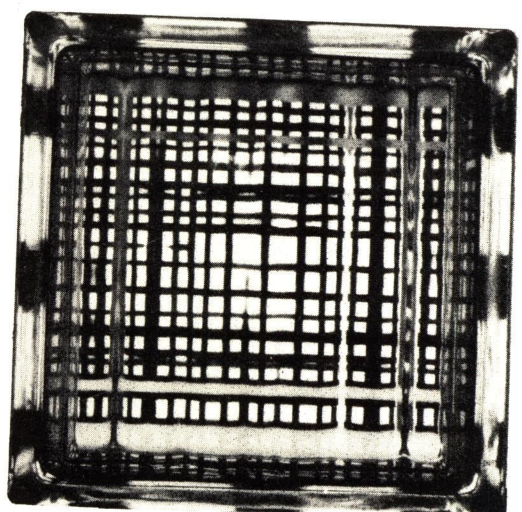


DECORA BLOCK. Pittsburgh-Corning

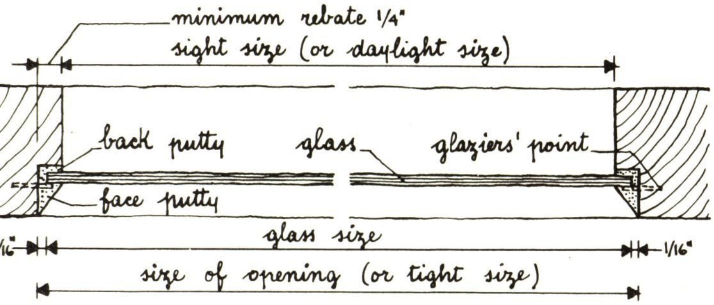
PHOTOGRAPHS AND SECTIONS
ONE THIRD FULL SIZE

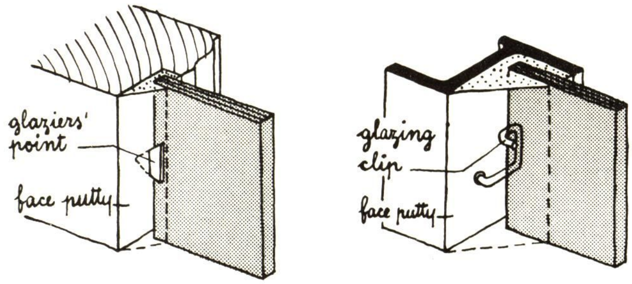


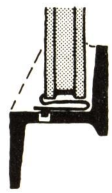
BRISTOL BLOCK. Pittsburgh-Corning
LIGHT TRANSMISSION 65%



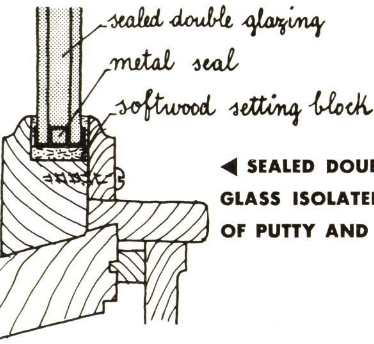
ARGUS BLOCK. Pittsburgh-Corning
LIGHT TRANSMISSION 80%



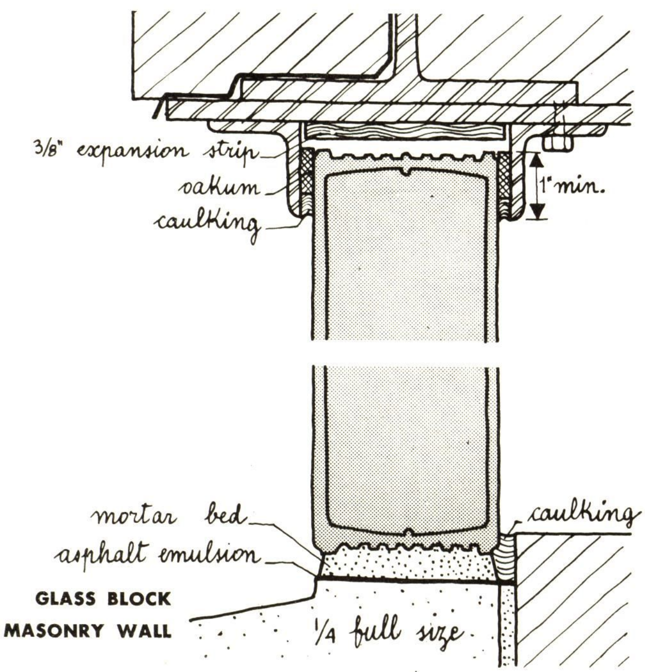




WINDOW PANES HELD BY *(LEFT)* GLAZIER'S POINTS, *(RIGHT)* SPRING CLIPS, FOR SINGLE GLASS *(TOP)* AND SEALED DOUBLE GLAZING ▶



◀ SEALED DOUBLE GLAZING IN WOOD FRAME. GLASS ISOLATED FROM FRAME BY SURROUND OF PUTTY AND GLAZING COMPOUND



GLASS BLOCK MASONRY WALL

INSTALLATION OF GLASS

Being a comparatively fragile material, glass must be installed in such a way that it is not subjected to any strain which might cause it to crack and shatter. In order that the glass may remain isolated from the normal deformations of the building, it must be set within a frame (which may be identical with the building frame—as shown on page 90—or subsidiary to it), and sized to give a floating fit—at least 1/16 in. all round on even the smallest light, and as much as ¼ in. all round on a big picture window. When sealed double glazing or tempered glass is used, it becomes particularly important to calculate frame and glass sizes exactly before ordering, for these types of glass cannot be trimmed after manufacture.

In ordering sheet glass, when specifying sizes, the width should always be stated first, then the height. The glass supplier can then cut a sheet with the "grain" running the long way so that any slight uneveness of surface is scarcely noticeable. In the case of certain patterned glass the standardized order of dimensions is even more essential.

Large sheets of glass must be handled with great care and skill. If held horizontally, or supported unevenly, they are liable to shatter of their own weight. So they are always carried on edge, supported as far as practicable along their entire length. When set in place in the frame they rest on setting blocks of some material such as lead or soft wood. At least two of these blocks are used, set in from each end about a quarter of the length of the whole sheet. Very long sheets may need more than two blocks, but then care must be taken to even their support.

To hold large sheets of glass securely within a frame, it is advisable to have a continuous rabbet or bead, of wood or metal, on each side of the glass edge. As glazing is normally done from outside, there is usually a fixed rabbet on the inside, a removable bead on the outside face. For smaller panes, where less support is needed, the glass is held against the rabbet by intermittent pegs. In wood sash these take the form of small triangular pieces of galvanized metal — glaziers' points — driven into the sash frame. In metal sash twisted wire clips wedge into holes in the frame, fulfil the same function of holding the glass in place. A fixed rabbet on the inside is normal, to give a finished effect on the inside face, and to allow for the customary glazing from the outside. Industrial windows (page 43) are an outstanding exception; they are glazed from inside, have the fixed rabbet outside.

In all these types of installation it is still considered the best practice to have the glass bedded in putty, so that there is no direct contact between glass and frame; a layer of elastic glazing compound and putty intervenes on every

side. Where there is no bead on the outside, face putty, in triangular section, is used to cover the glazing clips and points, and to give a neat, weatherproof finish to this joint.

The most desirable material for this cushion between glass and frame would be one which remains plastic indefinitely, has good adhesion, and is not affected by heat, cold, or damp. As this is an almost unfillable specification, there are very many different types of mastic and putty available. There is also an increasingly large number of rubber, plastic, and felt edgings which replace putty and mastic, and even, in some cases, double as a frame for the sash, a neat and entirely logical bit of co-ordination. Many modern windows, especially those of extruded aluminum, have eliminated the comparatively short-lived face putty by substituting a spring glazing bead. This acts also as a continuous glazing clip. Others protect the face putty with a metal cover.

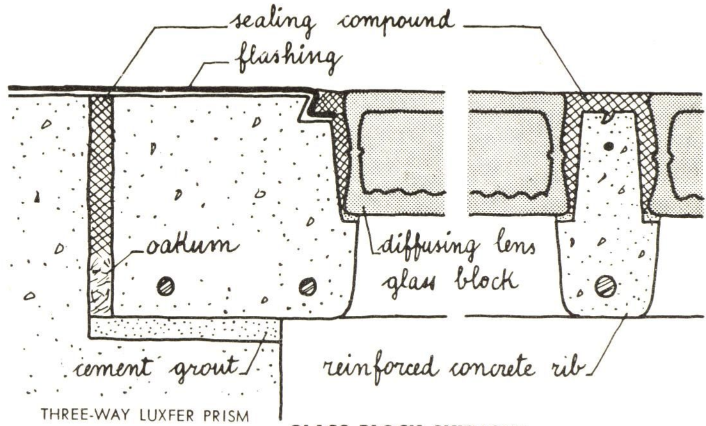
The minimum allowable rabbet is generally considered to be ¼ in., but in the case of sealed double glazing a deeper rabbet is needed to cover the metal edge of the glass which is almost ½ in. deep. Add to this a ¼ in. glazing clearance, and it will be seen that for large sheets of sealed double glazing a rabbet depth of as much as ¾ in. will be necessary. The rabbet width required is also, naturally, more than twice that need for single glazing.

Glass block has very little structural strength, so it must be framed in a fashion similar to sheet glass. There is an expansion strip at head and jambs of the panel, with oakum and calking stuffed between the faces of the block and the metal angles which are here acting as rabbet and bead. In larger panels metal ties must be added every few courses to give added strength. When used for roofing, glass blocks are generally isolated from the concrete frame by a waterproof elastic compound.

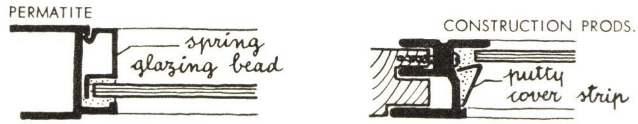
Puttyless glazing systems make far less effort to construct an absolutely waterproof joint. Instead, glazing bars are so designed that any water leaking in through the joint is immediately drained off by an integral metal channel or flashing mold. Similar provision is made in store window glazing (where a metal molding is kept in contact with the glass face by intermittent clips) for collecting and draining off the condensation which streams down the inside face of the window under certain conditions of temperature and humidity (see page 141). Similar precautions might well be taken in houses and other buildings where large glass areas are being used in severe climates.

In some systems of puttyless glazing a gasket of impregnated felt, or a rope washer of asbestos or similar material, seals the joint between the glass and the metal glazing bar with its screw-tightened cap. In other systems the glass is simply tucked in beneath a spring metal clip on the glazing bar.

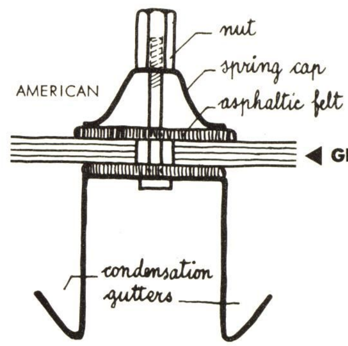
A similar principle is used in a double-hung window (Premier) where an unframed sheet of glass, sliding up and down in an aluminum channel, is held storm-tight by spring metal weatherstrips alone.



GLASS BLOCK SKYLIGHT

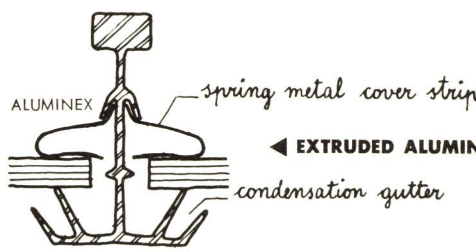


TWO WAYS OF ELIMINATING FACE PUTTY
***LEFT:* PUTTY COVER ON OUTSIDE. *RIGHT:* INSIDE GLAZING BEAD**



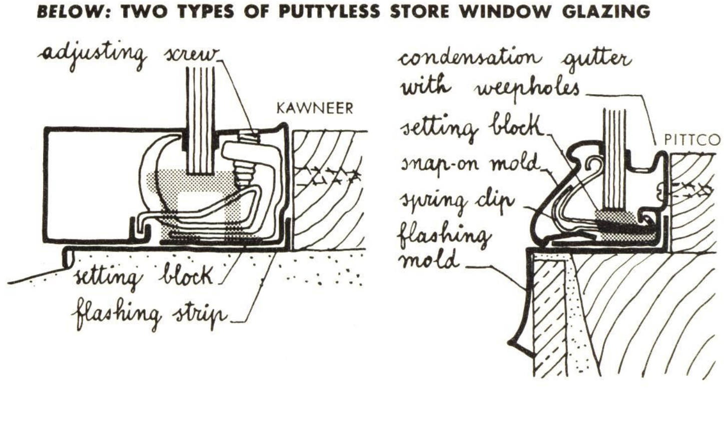
◀ **GLAZING BAR WITH SCREW CAP**

ALUMINUM DOUBLE-HUNG WINDOW ▶
WITH UNFRAMED SASH



◀ **EXTRUDED ALUMINUM GLAZING BAR**

***BELOW:* TWO TYPES OF PUTTYLESS STORE WINDOW GLAZING**

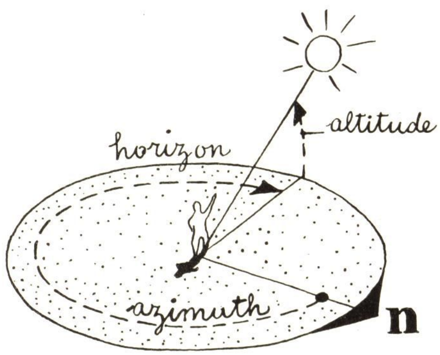


HOW TO CONTROL SUN, LIGHT, HEAT

Whether or not you enjoy direct sunlight is a matter of personal taste. Most people like its radiant warmth in winter (particularly as it may also be a fuel saver, cf. page 138), prefer to be shaded from that warmth in summer. To be satisfied, both likers and dislikers must protect themselves with some form of sun control. To design such a control requires a clear knowledge of the way in which the earth revolves about the sun, perpetually but very regularly, throughout the changing seasons.

GEOMETRY & MECHANICS OF THE SUN

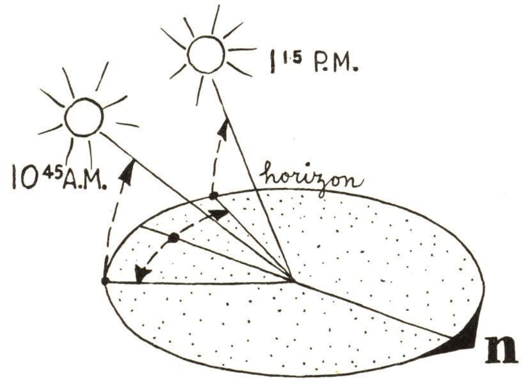
The direction of the sun's rays at any specified locality, day and hour can always be stated by two angular coordinates, azimuth and altitude. *Azimuth* is measured clockwise from True North on a horizontal plane. (When the



term *Bearing* is used, the angle is measured from north either clockwise or anti-clockwise, whichever is the smaller angle.) *Altitude* is measured upward from the horizon in a vertical plane. Azimuth and altitude vary with the hours of the day and the days of the year in an annual cycle which is symmetrical about its two extremes, the Summer Solstice (about June 21) and the Winter Solstice (about December 21). So the path of the sun through the sky on August 30, for example, sixty-three days *after* June 21, will be exactly the same as its path through the sky on April 10, sixty-three days *before* June 21.*

As climatic conditions in very many parts of the world (including the North American continent) are not symmetrical about this same point, direct sun may be desirable on only one of these dates, not on its twin. It follows that the shape and position of any fixed sunshade in such areas will necessarily be a compromise.

The path of the sun in any day is also symmetrical — about noon**. For example, the sun will have the same altitude and the same bearing (i.e., it will be an equal horizontal angle clockwise, or anti-clockwise as the case may be, from north) at 10:45 a.m. and at 1:15 p.m.

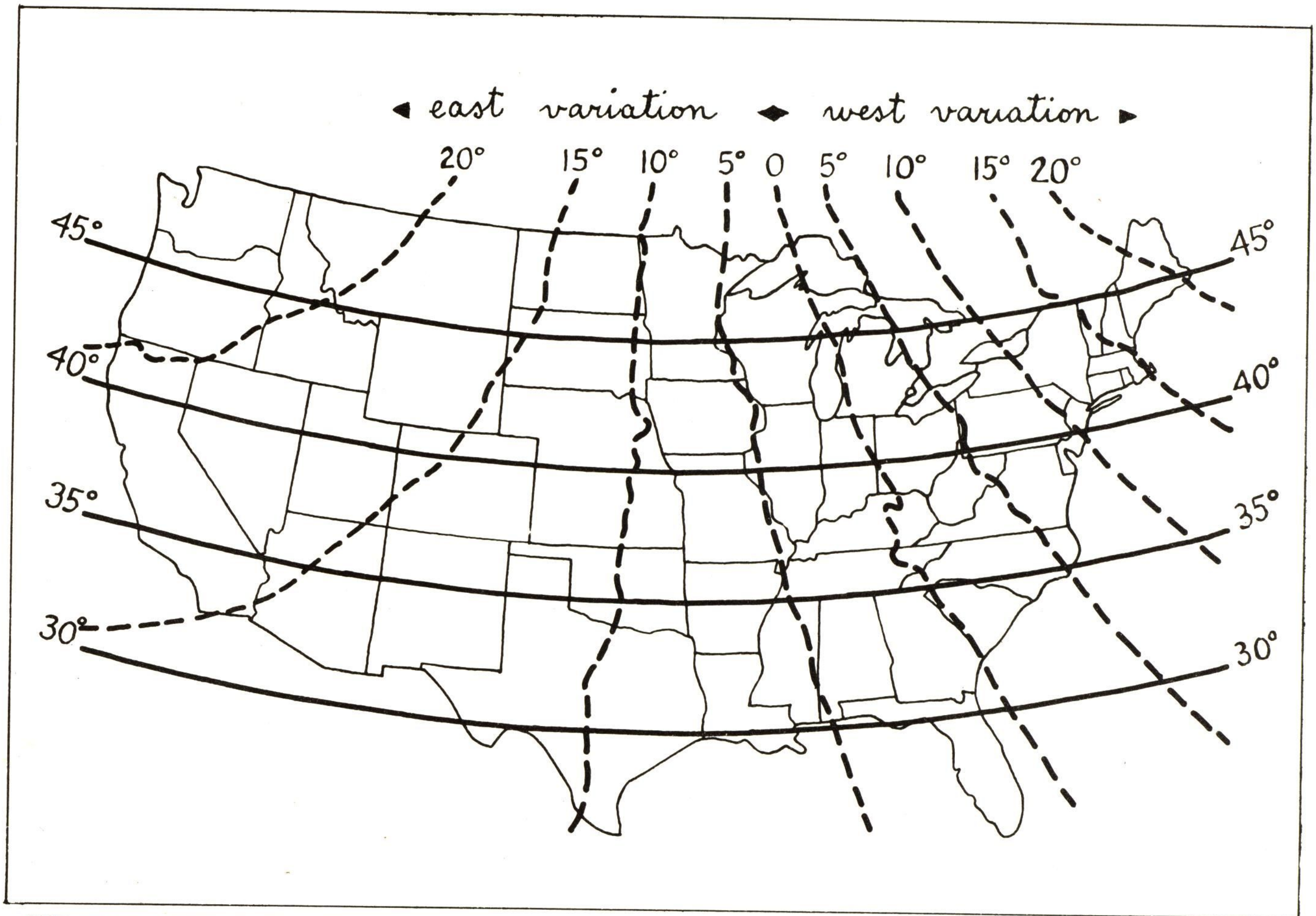


The angle of Azimuth is measured from True North. When the sun is exactly East its azimuth will be 90°, when it is exactly South its azimuth will be 180°, and so on. The sun's azimuth at noon in the northern temperate zone (which includes the U. S.) is always 180°.

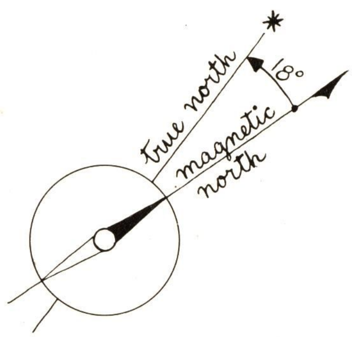
The True, or Geographic, North from which the azimuth or bearing angle is measured must not be confused with the somewhat temperamental Magnetic North given by a compass. The first essential in any problem of orientation is to determine the True North. If a surveyor is not at hand, take a compass reading and convert this to True North by applying the local magnetic variation as shown on the map on the next page. If the variation is a certain number of degrees *west,* the True North will be that many degrees clockwise from Magnetic North. If the variation is *east,* shift from Magnetic North anti-clockwise.

*To make the sun's movements more comprehensible we shall always describe them as they appear to an unlettered observer on the earth, i.e., as though the sun were revolving round the earth, a folk heresy perpetuated by the sun's "rising" and "setting".

**Throughout this section of the book when speaking of time we refer to Solar Time, the time you would read on a sundial, not on your 17-jewel. Rather old-fashioned, to be sure, but that is still the time on which the sun runs. For most ordinary calculations, this discrepancy is unimportant; the designer is usually more interested in the number of hours of sunshine than in their exact timing. That the sun's noon comes a half hour before or after the noon of your watch doesn't really matter much. If you insist upon extreme accuracy it will be necessary to take into account longitude, equation of time, sun's right ascension and declination (tabulated in the Nautical Almanac for that date); and you may end up trying to locate an astronomer.



MAP OF THE UNITED STATES WITH DOTTED LINES TO SHOW MAGNETIC VARIATION



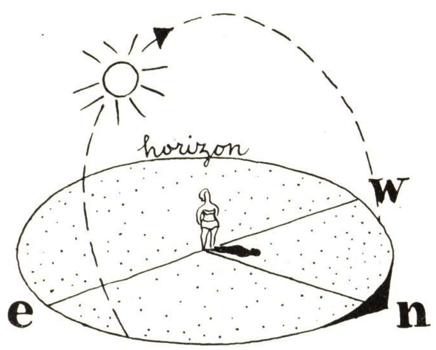
LOCATING TRUE NORTH FOR A LOCAL MAGNETIC VARIATION OF 18° EAST (SAN FRANCISCO)

The angle of Altitude is measured from the plane of the horizon. At sunrise and sunset the sun's altitude is, obviously, 0°. Its maximum altitude, reached only at noon in the tropics, is 90°. Its maximum altitude at Philadelphia, for example, is 73½°, at noon on the day of Summer Solstice.

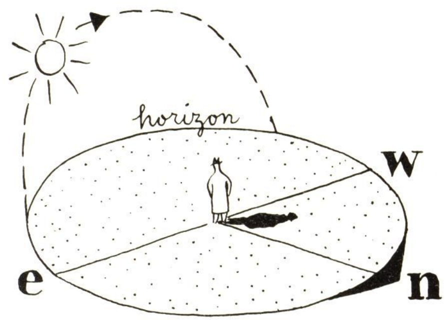
In order to use the figures of azimuth and altitude intelligently a designer should have at least a general knowledge of the sun's annual cycle. At the Spring Equinox (about March 21) the sun rises exactly in the East—azimuth 90°, altitude 0°—makes a gracious half circle in the sky and sets six hours later exactly in the West—azimuth 270°, altitude 0°.

This happens everywhere on the earth on that date. But the angle between the plane of the sun's path and the plane of the horizon will vary according to the observer's position on the earth. At the Equator the sun will pass directly overhead. The further north or south the more oblique will the plane of the sun's path become, until at the North or South Pole it will actually coincide with the plane of the horizon (altitude 0° throughout the day).

SUMMER AND WINTER SOLSTICE



SUMMER SOLSTICE: TEMPERATE REGIONS



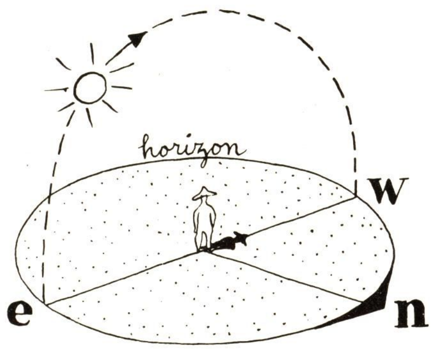
WINTER SOLSTICE: TEMPERATE REGIONS

In the northern hemisphere, as Spring gives way to Summer, the plane of the sun's path moves each day further toward the north. The sun rises to the north of east, sets to the north of west. But the angle between the plane of the sun's path and the plane of the horizon in any given locality remains constant. As the path of the sun at this period of the year is more than a half circle, there will be more than six hours of sunlight.

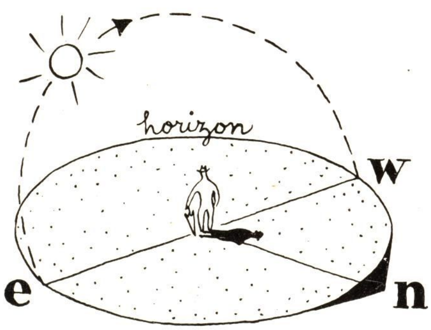
At the Summer Solstice (about June 21) this northward movement of the sun's path comes to an end. The sun starts to retrace its steps until, at the Fall equinox (about September 21) it has reached once again the position which it held at the Spring Equinox. It continues southward past this point, so that the sun rises to the south of east, sets to the south of west. The sun's path is less than half a circle, so there are less than six hours of possible sunlight.

At the Winter Solstice (about December 21) this southward movement of the sun's path comes to an end, and it starts to retrace its steps back north once again toward more hours of possible sunlight.

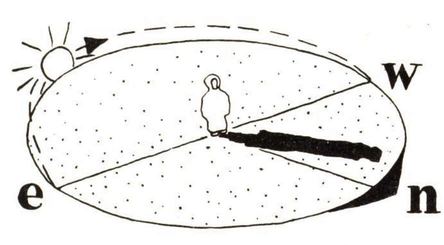
SPRING AND FALL EQUINOX



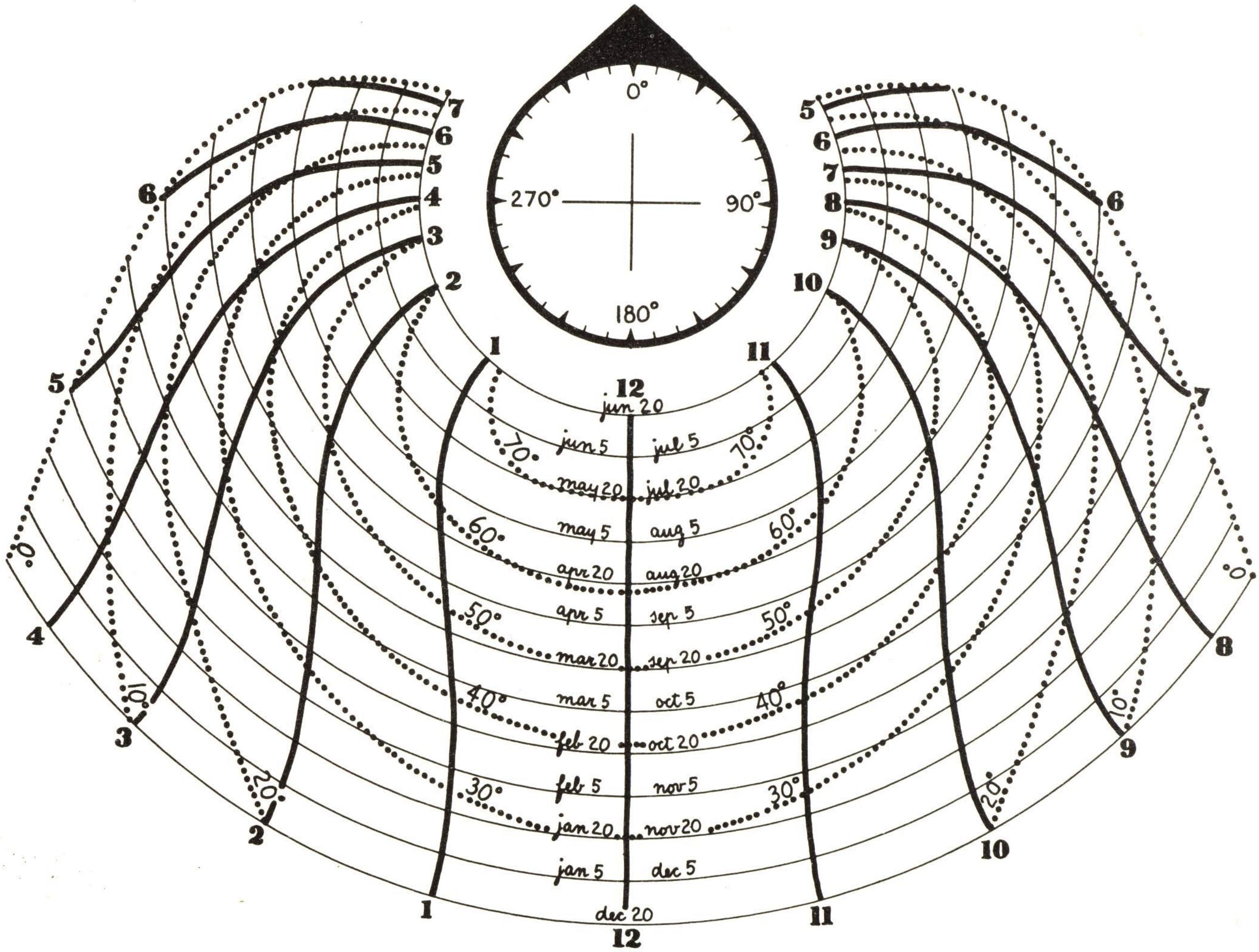
AT THE EQUATOR



IN THE TEMPERATE REGIONS

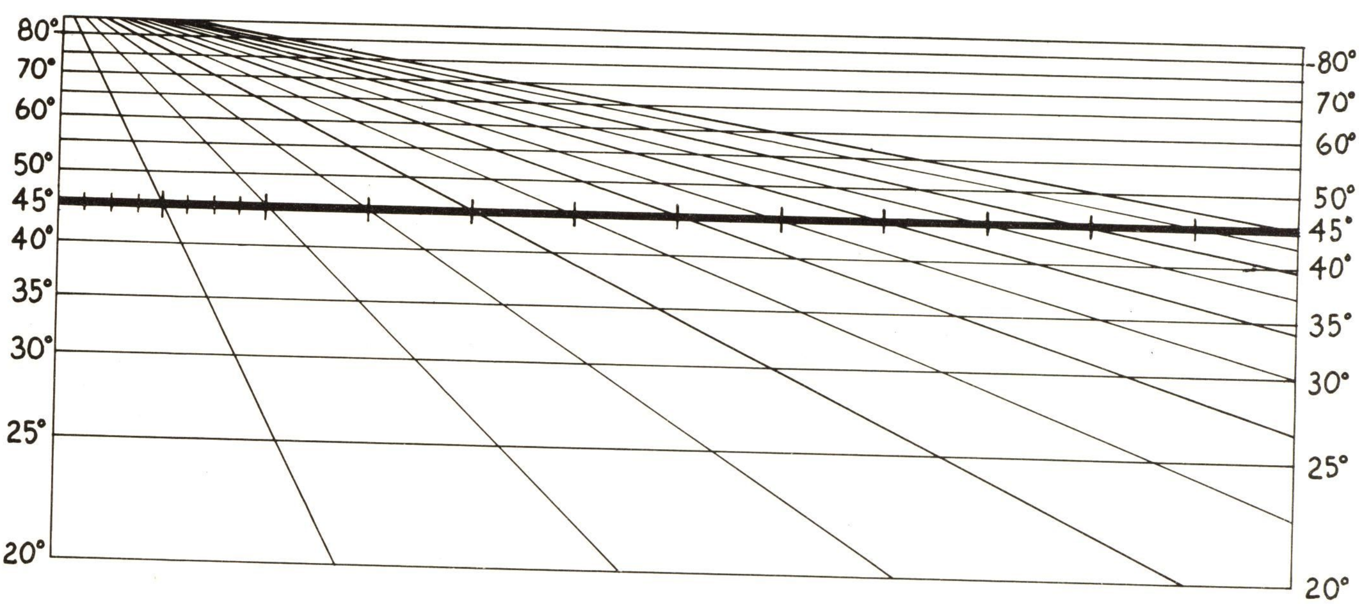


IN THE NORTH POLAR REGION



ABOVE: **SMALL-SCALE REPRODUCTION OF A BAKER-FUNARO SUNFINDER FOR LATITUDE 40° N**

BELOW: **SHADOW LENGTH SCALE FOR USE WITH SUNFINDER**



HOW TO CALCULATE THE SUN'S POSITION AT ANY TIME AND PLACE

Azimuth and altitude of the sun can be calculated for any time, date and latitude by solving two spherical trigonometry equations. This is time-consuming work, and at the end of each calculation one has the result for only a single hour and date, and its twin. For quick approximations the data given on page 137 may be sufficient. Far more useful to the designer are various devices which can be applied directly to models and drawings. For work with models, particularly when studying the shadows cast by neighboring buildings, the Heliodon (see page 8) will serve well enough. But for work on plans the Baker-Funaro SUNFINDER is one of the best graphic aids yet developed. It is available for latitudes from 25°-50° N. It shows graphically on a plan of any scale, without need for any section drawing, the direction of the sun's rays, and thus the direction of the cast shadows, for any date and hour. It also gives the length of shadow cast by an object of given height, transferred from the shadow length scale at the scale of the plan under consideration. Solar orientation and the design of sun shades becomes, with the SUNFINDER, a normal and easy part of drafting routine, instead of elaborate and lengthy calculations to be undertaken only by an expert. The following example will show how simply it works, and suggest some of its numberless possibilities.

How to design an overhang which will keep out most of the summer sun and let in most of the winter sun, for a room at 40° N latitude facing south-west, lit by a long picture window 4 ft. high with a sill 3 ft. above the floor.

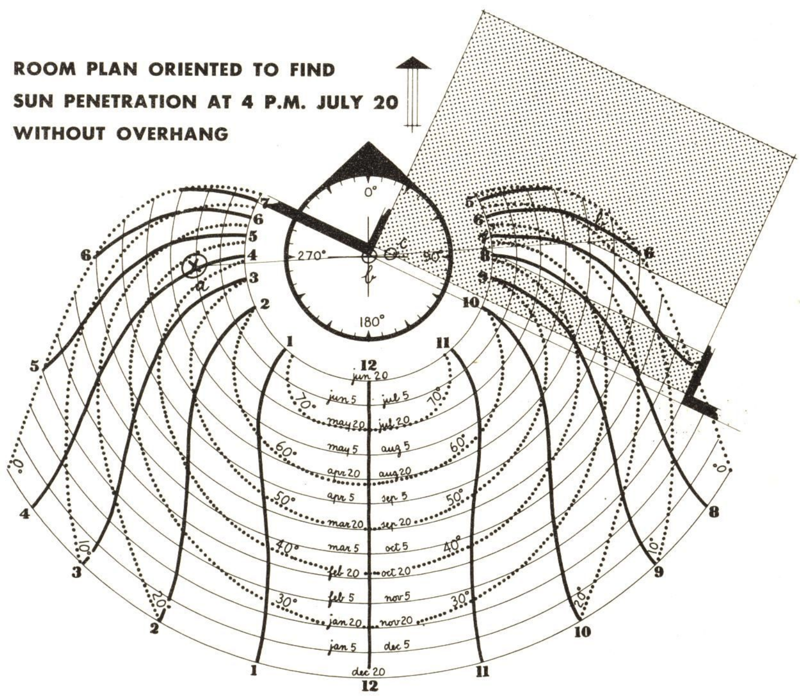
First, for a quick review, place a tracing of the plan over the SUNFINDER so that the center of the window opening is approximately over the center of the chart (the center of the orientation circle). The true north arrow on your plan must *always* lie parallel to the north arrow on the chart.

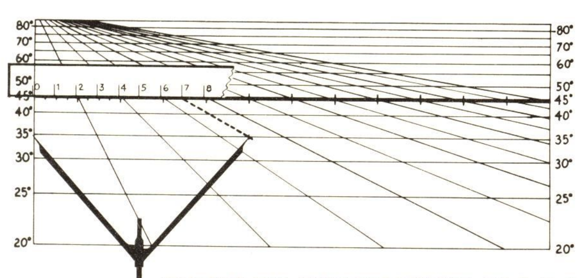
The direction of the sun's rays is given by connecting the intersection of the chosen hour and date lines with the center of the chart. Taking July 20 as an average summer condition, it is immediately obvious, without drawing, that the furthest, and therefore most objectionable, sun penetration on that date will be at about 4 p.m. Later the sun's rays will be almost parallel with the face of the building, and will not penetrate to any extent.

After this preliminary survey we slide the plan over until the north-west jamb of the window, which we can now see will cast the most important shadow in late afternoon, is over the chart center. Connect the point **a**, where the July 20 and 4 p.m. lines intersect, with the chart center and continue the line beyond it. This is the *direction* of the shadow cast by the window jamb. Its *length* will depend upon the sun's altitude, marked by dotted lines on the chart. The one which passes through **a** is 35°, and so this will be the altitude of the sun on July 20 at 4 p.m.

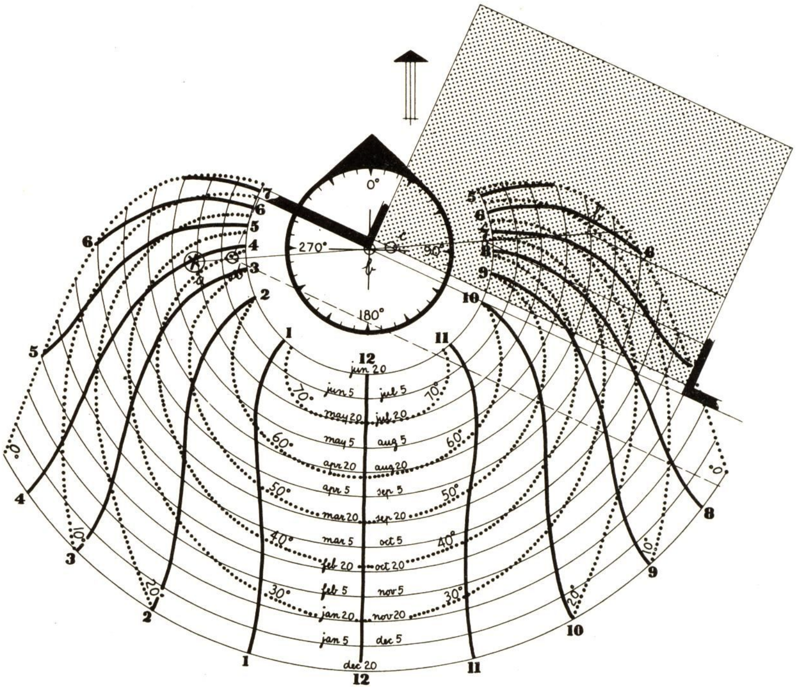
The window head is 7 ft. above the floor. Measure off this 7 ft., in the same scale as your plan, along the heavy 45° line of the *Shadow-Length Scale*. Then follow the converging lines up or down until you intersect the line of altitude in which you are interested, in this case 35°. From this inter-

ROOM PLAN ORIENTED TO FIND SUN PENETRATION AT 4 P.M. JULY 20 WITHOUT OVERHANG



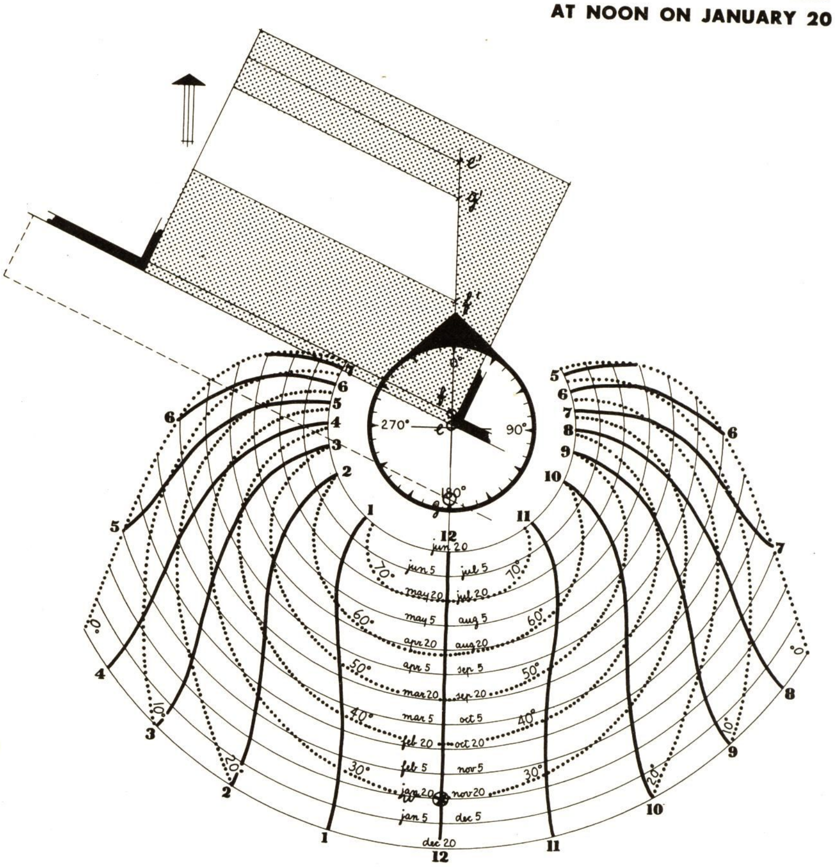


FINDING THE SHADOW LENGTH OF A 7 FT. HIGH OBJECT WHEN THE SUN'S ALTITUDE IS 35°



***ABOVE:* SUN PENETRATION AT 4 P.M. JULY 20 COMPLETELY STOPPED BY ADDITION OF OVERHANG**

***BELOW:* PENETRATION OF WINTER SUNLIGHT UNDER SAME OVERHANG AT NOON ON JANUARY 20**



section to the left edge of the scale will be the shadow length at the scale of your drawing. So transpose this length directly to your plan with a fixed point compass. Starting from **b** this will give you **b′**. Repeating the operation for a height of 3 ft. instead of 7 ft. will give the length of shadow cast by the sill. Starting from **c** it reaches **c′**.

Draw lines through **b′** and **c′** parallel to the window and you have delimited the patch of sunlight which will appear on the floor at 4 p.m. on July 20. Now how to block it.

How far the overhang is above the window head will determine to some extent its necessary width. For summer shading the closer the overhang is to the window head the less it need project; but full penetration of winter sun is not possible unless the overhang is a certain distance above the window head (see sketch on page 140).

We shall assume here that the overhang will be 1 ft. above the window head, i.e., 8 ft. above the floor. So find the length of shadow cast by an object 8 ft. high (in the same way as we have described above) and mark the distance on the plan outward from **c′**. It reaches **d**; so the edge of the overhang has to pass through this point, which is 3 ft. out from the wall. So the width of the overhang must be 3 ft.

It is obvious from the SUNFINDER that any such projection will be more than sufficient to provide complete shade in the earlier part of the day when the sun is higher in the sky.

To check winter conditions, use the same system to draw the sun penetration at noon in winter (January 20 was selected as an average winter day). Without an overhang the shadow cast by the window head would pass through **e′**. The overhang casts a shadow passing through **g′**, so it reduces slightly the winter sun penetration. At noon, however, the sun is at its maximum height; at any other hour of this day, because of the sun's lower altitude, the overhang will have no shading effect.

To design an overhang which would not cut the sun in winter at all, it is better to start from that requirement and work the whole process through backward to the summer conditions.

ALTITUDES AND BEARINGS OF THE SUN. LATITUDES 20° N TO 50° N

This table, intended for quick, approximate results only, is adapted from U. S. Hydrographic Publication No. 214. It is accurate to the nearest degree, and in the case of sunset and sunrise to the nearest hour. This table can be used for the same latitudes south of the Equator by changing the title of the June 21 line to read Dec. 21, and vice versa. The time is local solar time (see page 131). Bearing is the angle from North taken eastward in the morning, westward in the afternoon. Azimuth is always measured clockwise from North.

LATITUDE	HOUR	a. m. p. m.	4 8	5 7	6 6	7 5	8 4	9 3	10 2	11 1	NOON
20° N.	SEPT. 21 & MAR. 21	altitude			0°	14°	28°	42°	54°	65°	70°
		bearing			90°	95°	101°	109°	121°	142°	180°
	JUNE 21	altitude		0°	17°	21°	35°	48°	62°	76°	86°
		bearing		65°	70°	72°	76°	77°	77°	73°	0°
	DEC. 21	altitude				0°	17°	28°	38°	44°	46°
		bearing				115°	124°	133°	145°	160°	180°
25° N.	SEPT. 21 & MAR. 21	altitude			0°	14°	27°	40°	52°	61°	65°
		bearing			90°	96°	104°	113°	126°	148°	180°
	JUNE 21	altitude		0°	10°	23°	36°	49°	63°	76°	88°
		bearing		63°	68°	74°	78°	82°	87°	93°	180°
	DEC. 21	altitude				0°	14°	25°	33°	39°	41°
		bearing				116°	125°	134°	147°	162°	180°
30° N.	SEPT. 21 & MAR. 21	altitude			0°	13°	26°	38°	49°	57°	60°
		bearing			90°	98°	106°	117°	131°	152°	180°
	JUNE 21	altitude		0°	11°	24°	37°	50°	63°	75°	83°
		bearing		62°	69°	76°	82°	88°	96°	112°	180°
	DEC. 21	altitude				0°	11°	21°	29°	35°	36°
		bearing				117°	130°	136°	148°	163°	180°
35° N.	SEPT. 21 & MAR. 21	altitude			0°	12°	24°	35°	45°	52°	55°
		bearing			90°	99°	108°	120°	135°	155°	180°
	JUNE 21	altitude		0°	13°	25°	37°	49°	62°	73°	78°
		bearing		61°	70°	78°	85°	94°	106°	127°	180°
	DEC. 21	altitude				0°	8°	18°	25°	30°	31°
		bearing				119°	127°	137°	150°	164°	180°
40° N.	SEPT. 21 & MAR. 21	altitude			0°	11°	23°	33°	42°	48°	50°
		bearing			90°	100°	110°	123°	138°	157°	180°
	JUNE 21	altitude		0°	15°	30°	37°	49°	60°	69°	73°
		bearing		59°	72°	80°	89°	100°	114°	138°	180°
	DEC. 21	altitude				0°	5°	14°	21°	25°	26°
		bearing				121°	127°	138°	151°	165°	180°
45° N.	SEPT. 21 & MAR. 21	altitude			0°	11°	21°	30°	38°	43°	45°
		bearing			90°	101°	112°	125°	141°	159°	180°
	JUNE 21	altitude	0°	7°	16°	27°	37°	48°	58°	65°	68°
		bearing	55°	63°	73°	83°	93°	105°	121°	145°	180°
	DEC. 21	altitude					0°	10°	16°	20°	21°
		bearing					124°	139°	151°	165°	180°
50° N.	SEPT. 21 & MAR. 21	altitude			0°	10°	19°	27°	34°	38°	40°
		bearing			90°	102°	114°	127°	143°	161°	180°
	JUNE 21	altitude	0°	9°	18°	27°	37°	46°	55°	61°	63°
		bearing	51°	64°	74°	85°	97°	110°	127°	151°	180°
	DEC. 21	altitude					0°	6°	12°	16°	16°
		bearing					128°	139°	152°	166°	180°

SOLAR RADIATION AND THE TRANSFER OF HEAT THROUGH GLASS

In the calculation of sun controls (overhangs, baffles, etc.) more and more attention is being paid to the possible gain of solar heat during the winter months through large, southerly-facing windows. To the brightness and well-being which winter sunshine brings may now be added a dollars and cents bonus by saving on the cost of winter heating. However, if windows are to take full advantage of these opportunities, it is essential for the designer to have clearly in mind, first, the elementary rules of heat transfer, and second, the results of the latest research on this subject by the Purdue Research Foundation (set out in tabulated form on page 140).

Heat may be transferred through a window by transmission or by radiation. As far as comfort and cost is concerned, heat transfer by transmission is always flowing the wrong way. During cold weather heat expensively built up on the inside is lost to the outside, and during hot weather the heat which is transferred to the inside can only be eliminated by expensive cooling.

Heat radiated from the sun, on the other hand, due to the very high temperature of the sun itself, is a one-way trade. It produces a heat gain only. It will therefore be desirable or undesirable according to the season.

Heat rays from the sun pass through the window glass and heat whatever object they strike inside the building. That object then becomes warm and starts to reradiate, but these rays cannot escape through the window, for glass is opaque to this low-temperature radiation, transparent only to radiation from a high-temperature (above 500°F) source like the sun. So the glass acts as a trap for *radiant* heat. Though of course, as the air temperature is raised by contact with the sun-warmed surfaces, this heat is conveyed by air circulation, and when it touches the window is lost by transmission, if the temperature outside is sufficiently lower than that inside.*

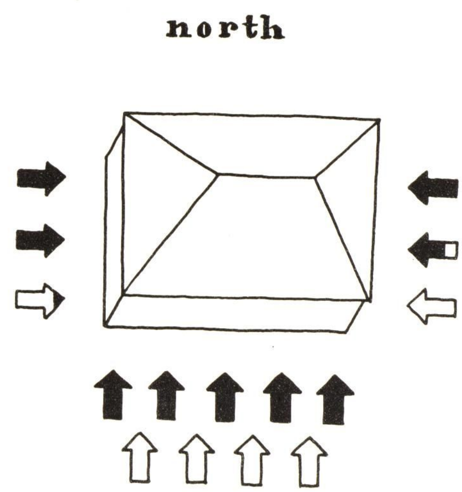
The two types of heat transfer—transmission and radiation—act independently. Transmission depends on the difference in air temperature inside and outside the window, and upon the thermal transmission coefficient (U value)** of the window. Radiation from the sun depends upon weather conditions, on the angle at which the sun's rays strike the glass, and on the transparency of the glass to those rays. The only effective way to control transmission is to reduce it, by decreasing the size of the windows, or by lowering their U value—by means of multiple glazing—so that it is as good or better than that of the surrounding wall. A low U value also helps to reduce condensation troubles (see page 141). The control of radiant heat is not as simple; and the simultaneous control of radiation and convection, which is what really counts, is still more complex.

U VALUES OF VARIOUS GLAZING

⅛ in. or ¼ in. glass	1.15
Sealed double glazing: with ¼ in. air space	0.63
with ½ in. air space	0.56
Glass block panel	0.47
Sealed triple glazing with ½ in. air space	0.39
Sealed quadruple glazing with ¼ in. air space	0.32

Control of solar radiation means letting it in when desirable, shutting it off when undesirable. In this nature is very helpful. The shifting of the sun's path during the seasons (see Geometry of the Sun, page 131) makes any south window an automatic control of solar radiation to a noticeable extent. The short and low path of the winter sun gives a south window more hours and deeper penetration of sunlight than the long and high trajectory of the summer sun (see table on page 140). Disregarding variations in local weather conditions, a south window anywhere in the United States during the winter heating

SUN HEAT GAIN ON VERTICAL WALLS IN WINTER



Each arrow represents 250 Btu per sq. ft. per day.
Together they total the maximum possible sunshine.
Solid arrows represent actual annual sunheat for New York City.

*This does not take into account actual exchange of air through open windows or through cracks between opening sash and frame. These are such unpredictable factors that we have not attempted to include them in any of the formulas given here. The ASHVE guide gives figures for the rate of air infiltration through window cracks in typical sash, which may be used if necessary as a basis for the calculation of heating equipment.

**U value = Btu per sq. ft. per hr. per degree F. difference in temperature.

season admits an hourly average of more than twice the solar heat that the same window admits in summer. If a properly designed overhang is added (see page 140) the heat gain during the heating season will remain unchanged, but the summer hourly heat gain will be reduced to one-third that of the winter. When overhangs and shades are not sufficient to eliminate all the undesirable radiant heat (e.g., west windows) the use of heat absorbing glass is advisable.*

SOLAR RADIATION THROUGH GLASS

Ordinary 1/8 in. clear glass is transparent to 85-90% of the solar radiation which strikes it. The rest is mainly reflected. *1/8 in. heat absorbing glass* is transparent to only about 50% of this solar radiation. The rest is mainly absorbed and then re-radiated as heat, half to the inside, half to the outside.

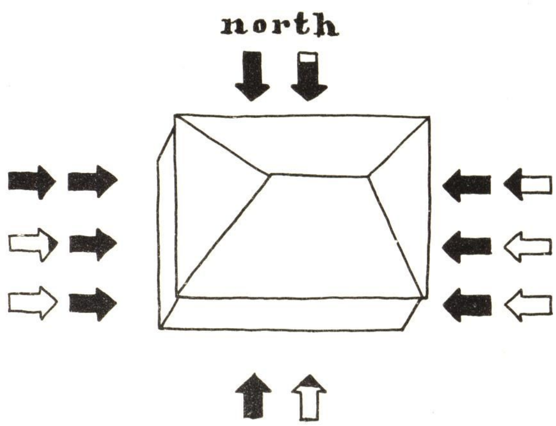
To be realistic, however, control of heat transfer through windows must include the simultaneous control of transmitted, as well as radiant, heat. This is at present the subject of elaborate research to evaluate, under realistic conditions, actual heat gain or loss with extensive use of glass on the south side of a house. It has been found by analysis and experiment that in most of the United States the total amount of solar heat entering a south window during the heating season is greater than the total heat loss by transmission through the same window. This gain is more pronounced if multiple glazing is used. Consequently, the cost of heating a house with large south windows should be lower than that of heating a similar house with fewer or smaller south windows. As an ultimate deduction the amount of radiant heat gained by larger and larger south windows would so far surpass the transmitted heat lost through these windows that no artificial heating at all would be necessary.

In practice, however, matters are not so clear-cut. Solar radiation comes in spurts. There are long periods with none at all. Then the heating plant quickly has to make up for the continuing heat loss by transmission through the large windows. Also it must be remembered that the greatest potential amount of solar heating through a south window is at the winter solstice—December 21 (see Geometry of the Sun, page 133). But the lowest winter temperatures don't normally occur until about a mouth later. So there is bound to be too much solar heating in the late fall, too little in the coldest part of winter.

For these reasons the heating system in a house designed for extensive use of solar heating has to be larger than in a conventional house of equal size, even though the fuel consumption is in total lower. Thus—talking only of dollars and cents—solar heating becomes advantageous only when the saving of fuel during the years makes up for the initial higher cost of a larger heating plant.

To design a house for the most efficient harnessing of solar heat may also imply certain less obvious added costs of construction (primarily due to the more elongated form of the building). Also the greater heat transmission during the summer from the outside with these larger windows will increase cooling costs.

SUN HEAT GAIN ON VERTICAL WALLS IN SUMMER



Each arrow represents 250 Btu per sq. ft. per day.
Together they total the maximum possible sunshine.
Solid arrows represent actual annual sunheat for New York City.

SOLAR HEAT: GAINS & LOSSES

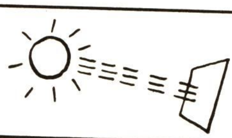
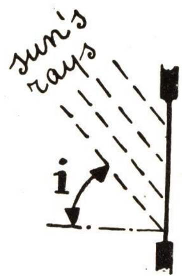
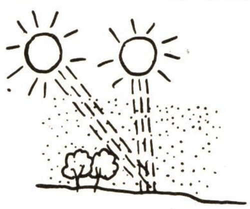
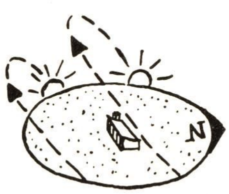
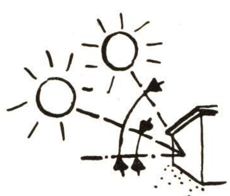
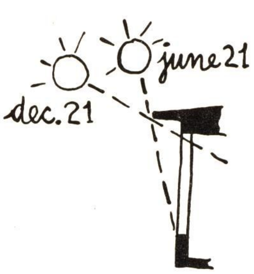
For practical design computations it can be assumed that the average hourly heat gain from solar radiation through a south window is 57.2 Btu.** This is during the seven-month heating season, October 1 to May 1, for an ideal condition of continuous clear weather. The average is taken over the total number of hours, both day and night, in this seven-month period.

This value of 57.2 Btu is assumed constant for a range of latitude covering the whole United States for single and double-glazed windows (heat reception through single glass is very slightly better). The variations caused by difference in latitude and in type of glazing can be safely disregarded, because they have a comparatively small in-

*This type of glass stops much of the *radiant* heat, as opposed to sealed double glazing with standard clear or figured glass which cuts down only *transmitted* heat.

**Information in this section based on findings by the Purdue Research Foundation (F. W. Hutchinson, *The Solar House — A Research Progress Report*). Diagrams at bottom of pages 138 and 139 based on data from *Solar Radiation* by Henry N. Wright — John B. Pierce Foundation.

RADIANT HEAT GAIN THROUGH A SOUTH WINDOW DURING THE HEATING SEASON (OCT. 1—MAY 1), AND DURING SUMMER

			HEATING SEASON	SUMMER
1		The radiant heat received by a surface perpendicular to the sun's rays is approximately 260 Btu/hr/sq. ft.	260	260
2		A surface which is not perpendicular to the sun's rays receives a smaller intensity of radiation, equal to 260 x cos **i**. Notice that on a south window in winter the average angle of incidence is smaller than in summer because the sun is lower in the sky (see Geometry of the Sun, page 132). In the diagram at left **i** = angle of incidence. Average **i** on a south window—from the time when the sun starts to strike the window to the time when it stops—through the heating season is 53.3°, in summer is 68°.	260 x cos 53.3 = 151	260 x cos 68 = 98
3		To the direct solar radiation must be added the indirect or sky radiation. Caused by the scattering effect of dust and water vapor in the atmosphere, this is greater in winter, when the sun is low (32 Btu/hr./sq. ft.), than in summer (16 Btu/hr./sq. ft).	151 + 32 = 183	98 + 16 = 114
4		A south window is irradiated by the sun's rays during only a part of the 24 hour day. Because of the seasonal shift of the sun's path in the sky this period is longer during the heating season (42% of a 24 hr. day) than in summer (37% of a 24 hr. day).	183 x .42 = 77	114 x .37 = 42
5		Not all the solar energy that strikes the window goes through the glass. Part of it is reflected and lost. The smaller the angle of incidence of the sun's rays the smaller the loss by reflection. This is why in the heating season, when the sun is low, the average percentage of transmission (76%) is greater than in summer (63%).	77 x .76 = 58.5	42 x .63 = 26.5
6		A properly designed overhang over a south window can greatly reduce the penetration of summer sun with little effect on the penetration span in winter. With the overhang shown at left irradiation during the heating season is reduced to 96%, during the summer to 75%. For best results an overhang should exclude *all* sun at noon of June 21 only, should admit *all* sun at noon of December 21 only.	58.5 x .96 = 57.2 Btu/hr/sq. ft.	26.5 x .75 = 19.8 Btu/hr/sq. ft.

fluence on computations of heat gains and losses as compared with outside temperature and percentage of sunshine, which vary considerably according to the locality.

The table on the opposite page outlines the principal steps leading to the 57.2 Btu constant and also explains why the heat gain through the same window is much smaller in summer than during the heating season.

The table below shows application of the solar heat constant (57.2) in computing net heat gains and losses through a south window during the heating season for five cities in the United States.

From the figures below it is evident that large south-exposed windows are most satisfactory in localities which enjoy a mild climate and a high percentage of actual sunshine. The last line of the table shows how all of the five cities, which have been selected as representative of extreme climatic conditions in the United States, have some net gain when the windows are equipped with double glazing. How much of this theoretical net heat gain can be used advantageously under practical conditions depends on the ability to transform an intermittent and unforeseeable income of free energy into regulable comfort conditions.

AVERAGE HEAT GAINS AND LOSSES PER HOUR PER SQ. FT. OF SOUTH WINDOW

DURING THE PERIOD OCT. 1—MAY 1 (5088 HOURS) FOR FIVE CITIES IN THE UNITED STATES

	City	Indianapolis	Minneapolis	New Orleans	New York	San Francisco
F: Ratio of average actual to maximum possible sunshine hours		.507	.527	.370	.550	.615
S = F x 57.2: Average solar heat gain (Btu)		29	30.2	21.2	31.4	35.2
T: Average outside temperature		40.3°	29.4°	61.6°	40.7°	54.2°
C = (70-T) x U: Heat loss by convection (Btu)	for single glass (u=1.13)	33.6	46	9.4	33	17.8
	for double glass (u=.6)	17.8	24.4	5	17	9.5
G = S-C: Net gain or loss (Btu)	for single glass	—4.6	—15.8	11.8	—1.6	17.4
	for double glass	11.2	5.8	16.2	14.4	25.8

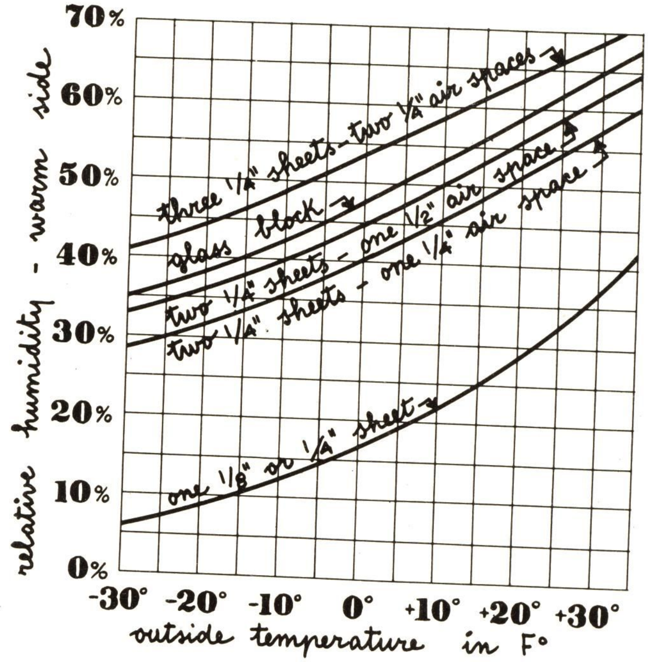
CONDENSATION ON WINDOWS

Condensation on a window is a predictable phenomenon, the causes of which are not difficult to understand. The air is a mixture of gases, one of which is water vapor. There is a limit to the quantity of water vapor that can be held by the air in a gaseous state; when this limit is reached the air becomes saturated. Any additional water vapor added to saturated air immediately condenses.

The capacity of air to hold water vapor varies with the air temperature; the lower the temperature the smaller the capacity. So air may become saturated simply by lowering its temperature; then there will be condensation without any water vapor being added.

How close air is to saturation is shown by its *relative humidity,* the percentage ratio between the amount of water vapor actually in the air and the amount required to saturate the air at the same temperature. Relative humidity can be raised either by increasing the water vapor content or by lowering the temperature. When the relative humidity reaches 100% there will be condensation.

What happens in a comfortably heated room in cold weather? The air is warm and has a considerable amount of relative humidity — from 20% to 60% is required for comfort. The temperature of the air in contact with the cold windows drops. The relative humidity increases, reaches 100%, and water starts to condense on the windows. If the temperature on the inner surface of the windows is below freezing the condensation immediately becomes frost. If the conditions causing condensation persist, the condensation will accumulate; if frost it will



CONDENSATION POINTS ON THE WARM SIDE (INSIDE) OF A WINDOW WALL FOR A CONSTANT ROOM TEMPERATURE OF 70° F. NORMAL AIR MOVEMENT (CONVECTED HEAT) ON THE INSIDE

become thicker, if moisture it will keep running down the surface of the window.

Condensation troubles are more frequent in modern, well-insulated houses than in old buildings. The moisture-laden air has less chance to escape from a compact, tightly-built and well-insulated house. From kitchen, bathrooms, laundry, and indoor gardens, moist air spreads quickly through a small house with open plan, and finds many large cold window areas upon which to condense.

What to do about it? Decrease the conductivity of the windows—glass and sash—by the use of multiple glazing. Avoid exposed cold metal surfaces in the building. Avoid excessive relative humidity. Wipe off the inner surface of the windows with a stream of warm, dry air. If there is a localized source of vapor, such as a laundry, bathroom or kitchen, provide local ventilation to prevent the spread of water vapor through the building. Whenever there is a foreseeable cause of condensation which cannot be eliminated, provide condensation gutters, drains, weepholes, so that the moisture can be disposed of quickly, without damage to the building.

The chart above indicates exterior temperatures and relative humidities at which condensation is to be expected with single glass and multiple glazing. It is assumed that the interior temperature is maintained at 70°, and the interior air free to circulate by natural convection.

CREDITS AN

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